
KSC Ice/Frost/Debris Assessment For Space Shuttle Mission STS-30R

May 1989

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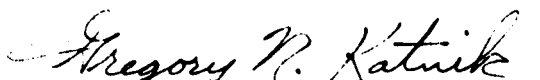
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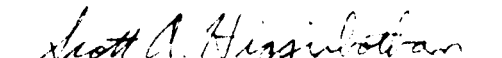
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**ORIGINAL CONTAINS
COLOR ILLUSTRATIONS**

KSC
ICE/FROST/DEBRIS ASSESSMENT
FOR
SPACE SHUTTLE MISSION
STS-30R
MAY 4, 1989

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Approved:
May 31, 1989


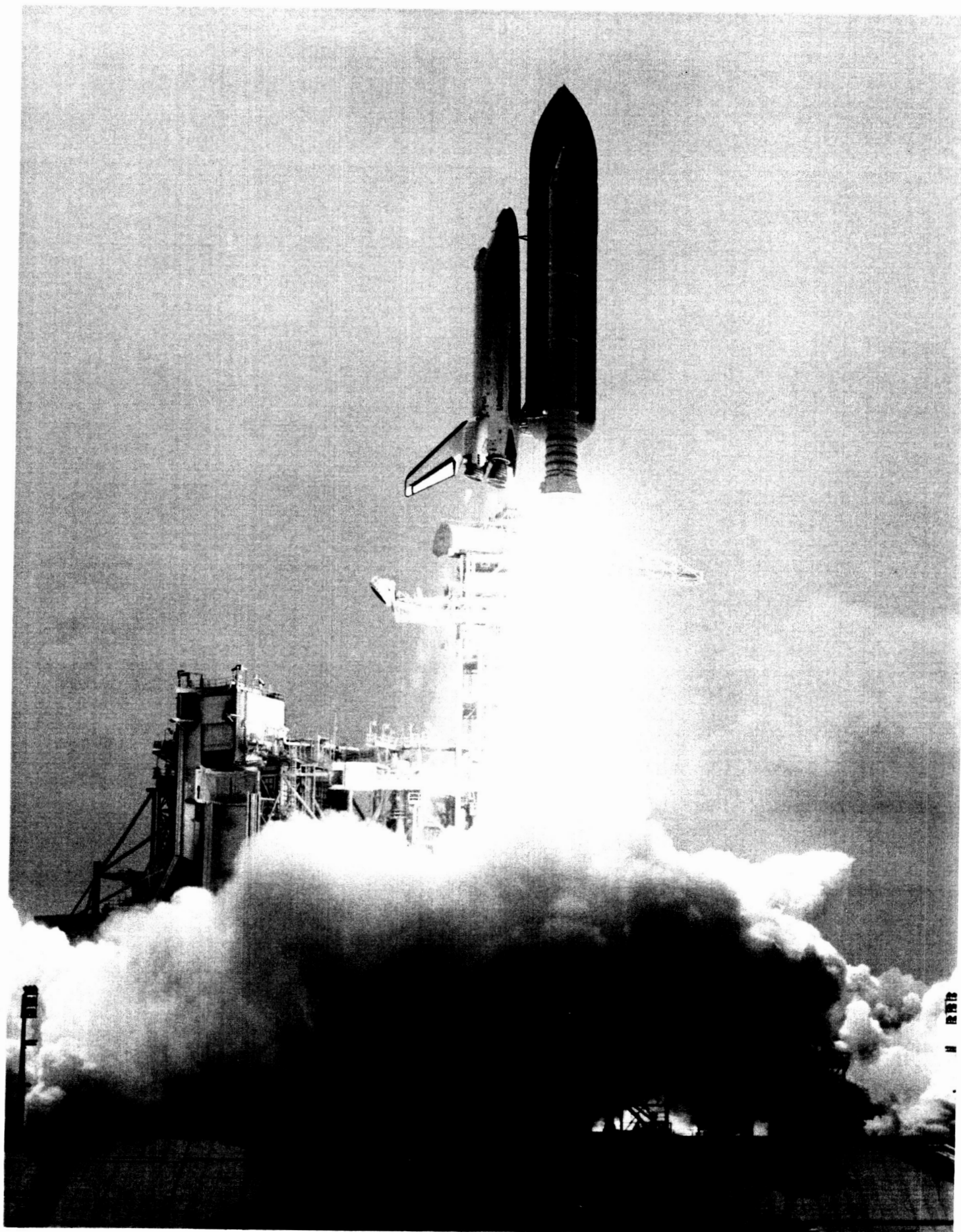

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FORWARD

The Debris Team is continuing its effort to develop and implement measures to control damage from debris in the Shuttle operational environment and to make the control measures a part of routine processing and operations.



SUCCESSFUL LAUNCH OF SPACE SHUTTLE MISSION STS-30R

1.0 Summary

Ice/Frost/Debris Team activities for Mission STS-30R began with the pre-launch debris inspection of the launch pad and Shuttle vehicle on 27 April 1989. No major anomalies were observed on OV-104 Atlantis, BIO-27, or ET-29. Minor facility discrepancies, which included untorqued MLP deck bolts and loose electrical box covers, were corrected prior to cryo loading the vehicle.

The first launch attempt on 28 April 1989 was scrubbed at T-31 seconds due to a malfunction of the SSME #1 LH2 recirculation pump. An extended scrub turnaround was initiated. After the launch was scrubbed, vapors were observed during the detank operations emanating from the LH2 recirculation line burst disc area nearest the ET. The velocity and directional attitude of the vapors gave the appearance that the burst disc had ruptured. This event prompted the removal and replacement of the line during post drain operations.

The defective recirculation line was returned to the vendor (Arrowhead, California) for failure analysis. When the argon-filled bellows cavity was opened, the argon gas charge was still present. No anomalies were found with the bellows by the vendor. Subsequent LH2 cryogenic flow testing on the line was performed at MSFC and indicated liquid air cryopumping through the SLA material could occur. A 1/2 inch circumferential crack was discovered through the SOFI adjacent to the burst disc which could produce liquid air and some vapor. However, neither the vapor volume, flow rate, or pressure to match that observed during the hold/detank could be duplicated.

An initial post drain inspection of the vehicle was conducted on 28 April 1989. No visible TPS damage was detected by the inspection team on the LH2 recirculation line, aft dome, or tank acreage. Examination of the outside cover of the recirculation line burst disc showed no visual damage. A typical quantity of ice remained in the LH2 feedline bellows, LH2 recirculation line bellows, and LO2 feedline support brackets. A detailed, hands-on post drain inspection of the vehicle was conducted on 29 April 1989. Loose foam in an area between the LO2 feedline support brackets and the Intertank was removed.

A second pre-launch debris inspection was performed on 3 May 1989. No major vehicle anomalies were detected. Only two minor facility discrepancies were noted. One bolt on the MLP deck was untorqued and vacuum putty in 20 MLP deck bolt holes required removal. These items were corrected prior to vehicle tanking.

ET-29 was cryo loaded for the second time on 4 May 1989. Infrared measuring devices recorded average temperatures (F) of 75 deg on the Intertank, 76 deg on the SRB cases, 83.5 deg on the SRB field joints, and 78 deg on the Orbiter surfaces. Due to sunlight and shadow, temperatures ranged from 62 to 65 deg

on the LO2 tank and from 60 to 72 deg on the LH2 tank. Typical accumulations of ice/frost were present in the LO2 feedline bellows and support brackets and on both ET/ORB umbilicals. Nine ice/frost console observation anomalies were documented and found acceptable for flight per the LCC and NSTS-08303. A 6-inch long crack in the shape of an inverted "Y" was detected on the LH2 umbilical -Z surface by the Ice Inspection Team. This crack was in the MBO-130-149 foam between the 17-inch feedline and the recirculation line and was documented on a PR. Since the crack was outlined by frost only and exhibited no debonding, it was dispositioned to use-as-is per MRB action. In general, ice and frost accumulations were similar to those noted on previous missions. At launch, the ET ice condition was well within the launch data base for ice formation. The special hydrogen sensor line that was attached to the LH2 umbilical for this flight detected no significant hydrogen during the cryo load and was successfully removed by the Ice Inspection Team during the T-3 hour hold.

After a successful launch at 14:47 GMT, a post launch debris inspection of Pad 39B was performed. No significant flight hardware or TPS material (including the body flap hinge tile piece lost at SSME ignition) was found. South holddown post shim material was intact, but had debonded from the shoe sidewall on holddown posts #1 and #2. All of the north holddown post doghouse blast covers were in the closed position. Overall, the facility sustained minimal damage.

A total of 132 film and video items were analyzed as part of the post launch data review. No major vehicle damage or lost flight hardware was observed that would have affected the mission. A few minor anomalies were noted. A 6"x3"x1" piece of black tile from the body flap hinge area near SSME #3 was shaken loose during SSME ignition. The hat band #7 thermal insulation blanket on SSME #1 came loose during ignition. Many pieces of debris fell from the vehicle during ascent. Most of these items have been identified as SSME frost, RCS paper covers, instafoam particles from the SRB aft skirts, umbilical ice, and pieces of foam from the ET Intertank region. No unusually heavy ice or vapor (as seen on STS-29R) was visible in the ET/ORB umbilical area during launch. As was the case for STS-29R mission, the airborne tracking coverage was of little analytical value.

The recovered Solid Rocket Boosters exhibited minimal damage. The RH FWD assembly had 82 TPS debonds and 2 divots while the LH FWD assembly had 104 debonds and 2 divots. The TPS and Hypalon topcoat continues to have adhesion problems with widespread blistering, peeling, and cratering. Some of the blisters revealed a combination of paint and MSA indicating the formation of divots within the TPS. The phenolic plate was delaminated on the +Z LH RSS antenna and the -Z LH RSS antenna sustained a crack and missing piece (1"x1/2") on the aft end of the SIA 220. Numerous GEI MSID labels were missing from both

boosters. Forty-two labels were completely missing and 22 were partially missing. All factory and field joint closeouts were intact except for the LH aft factory joint which had aft edge debonding on three of its EPDM weather seals. The LH SRB #2 main parachute failed to inflate and the booster impacted the water at a higher than normal velocity causing damage to three stiffener rings, the IEA cover, and the nozzle snubber ring. The aft BSM nozzle rings continue to lose K5NA. Six of the eight aft skirt holddown post debris containers did not work properly. Many pieces of booster cartridges, detonators, and frangible nut were lost from the containers as a result of the debris plungers not seating properly.

The Orbiter post landing inspection was conducted on 8-9 May 1989 at Ames-Dryden (EAFB) on the concrete Runway 22 and in the Mate/Demate Device (MDD). The Orbiter TPS sustained a total of 151 hits, of which 56 had a major dimension of one inch or greater. The Orbiter lower surface had a total of 134 hits, with 52 greater than 1 inch. The majority of the lower surface damage was concentrated aft of the LH main landing gear. This damage appears to have been caused by rubber debris from the LH MLG tires which shed material upon landing/rollout. This area had a total of 70 hits with 45 greater than 1 inch. With this damage excluded from the total count, the lower surface had a total of 64 hits, with 7 greater than 1 inch. Based on these numbers, comparison to statistics from 22 previous missions of similar configuration (excluding missions STS-24, 25, 26, 26R, and 27R which had damage from known debris sources), the total number of hits on the lower surface is lower than normal. Also, based on the severity of damage as indicated by surface area and depth, this flight is considered to be better than average. Two significant anomalies were noted during the post landing Orbiter inspection. A pyrotechnic retainer yoke fell from the ET/ORB LO2 umbilical to the runway surface when the ET doors were opened after rollout. A similar piece of hardware was discovered on the runway surface after the landing of STS-26R. Orbiter window #6 sustained an impact hit that left a pit 0.102"x0.092"x0.0115" in size. This damage is severe enough to require window replacement. The source of the damage has not yet been determined.

A total of 20 Post Launch Anomalies flight type anomalies were observed during this review.

2.0 KSC ICE/FROST/DEBRIS TEAM ACTIVITIES

Team Composition: NASA KSC, NASA MSFC, NASA JSC,
LSOC SPC, RI - DOWNEY, MMMSS,
USBI - BPC, MTI

Team Activities:

1) Prelaunch Pad Debris Inspection

Objective: Identify and evaluate potential debris material/sources. Baseline debris and debris sources existing from previous launches.

Areas: MLP deck, ORB and SRB flame exhaust holes, FSS, Shuttle vehicle external surfaces

Time: L - 1 day

Requirements: OMRSD S00U00.030 - An engineering debris inspection team shall inspect the shuttle and launch pad to identify/resolve potential debris sources. The prelaunch vehicle/pad configuration shall be documented/photographed.

Documents: OMI S6444

Report: Generate PR's and recommend corrective actions to pad managers.

2) Launch Countdown Firing Room 2

Objective: Evaluate ice/frost accumulation on the shuttle vehicle and/or any observed debris utilizing OTV cameras.

Areas: MLP deck, FSS, Shuttle vehicle external surfaces

Time: T - 6 hours to Launch + 1 hour or propellant drainback

Requirements: OMRSD S00FB0.005 - Monitor and video tape record ET TPS surfaces during loading through prepressurization.

Documents: OMI S0007, OMI S6444

Report: OIS call to NTD, Launch Director, and Shuttle managers. Generate IPR's.

3) Ice/Frost TPS and Debris Inspection

Objective: Evaluate any ice formation as potential debris material. Identify and evaluate any ORB, ET, or SRB TPS anomaly which may be a debris source or safety of flight concern. Identify and evaluate any other possible facility or vehicle anomaly.

Areas: MLP deck, FSS, Shuttle vehicle external surfaces

Time: T - 3 hours (during 2 hour BIH)

Requirements: OMRSD S00U00.020 - An engineering debris inspection team shall inspect the shuttle for ice/frost, TPS, and debris anomalies after cryo propellant loading. Evaluate, document, and photograph all anomalies. During shuttle walkdown inspect orbiter aft engine compartment (externally) for water condensation and/or ice formation in or between aft compartment tiles. An IR scan is required during the shuttle inspection to verify ET surface temperatures. During shuttle walkdown, inspect ET TPS areas which cannot be observed by the OTV system.

Documents: OMI S0007, OMI S6444

Report: Briefing to NTD, Launch Director, Shuttle management; generate IPR's.

4) Post Launch Pad Debris Inspection

Objectives: Locate and identify debris that could have damaged the Shuttle vehicle during launch.

Areas: MLP deck, flame exhaust holes and trenches, FSS, pad surfaces and slopes, extension of trenches to perimeter fence, walkdown of the beach from Playlinda to Complex 40, aerial overview of inaccessible areas.

Time: Launch + 3 hours (after pad safing, before washdown)

Requirements: OMRSD S00U00.010 - An engineering debris inspection team shall perform a post launch pad/area inspection to identify any lost flight or ground systems hardware

and resultant debris sources. The post launch pad/area configuration shall be documented/photographed.

Documents: OMI S0007, OMI S6444
Report: Initial report to LTD and verbal briefing to Level II at L+8 hours; generate PR's.

5) Launch Data Review

Objective: Detailed review of high speed films video tapes, and photographs from pad cameras, range trackers, aircraft and vehicle onboard cameras to determine possible launch damage to the flight vehicle. Identify debris and debris sources.

Time: Launch + 1 day to Launch + 6 days

Requirements: OMRSD S00U00.011 - An engineering film review and analysis shall be performed on all engineering launch film as soon as possible to identify any debris damage to the space shuttle vehicle. Identify flight vehicle or ground system damage that could affect orbiter flight operations or future SSV launches.

Documents: OMI S6444
Report: Daily reports to Level II Mission Management Team starting on L+1 day through landing; generate PR's.

6) SRB Post Flight/Retrieval Inspection

Objective: Evaluate potential SRB debris sources. Data will be correlated with observed Orbiter post landing TPS damage.

Areas: SRB external surfaces (Hangar AF, CCAFS)

Time: Launch + 24 hours (after on-dock, before hydrolasing)

Requirements: OMRSD S00U00.013 - An engineering debris damage inspection team shall perform a post retrieval inspection of the SRB's to identify any damage caused by launch debris. Any anomalies must be documented/photographed and coordinated with the results of the post launch shuttle/pad area debris inspection.

Documents: OMI B8001
Report: Daily reports to Level II Mission Management Team. Preliminary report to SRB Disassembly Evaluation Team. Generate PR's.

7) Orbiter Post Landing Debris Damage Assessment

Objective: Identify and evaluate areas of damage to Orbiter TPS due to debris and correlate, if possible, source and time of occurrence. Additionally, runways are inspected for debris and sources of debris.

Areas: Orbiter TPS surfaces, runways

Time: After vehicle safing on runway, before towing

Requirements: OMRSD S00U00.040 - An engineering debris inspection team shall perform a prelanding runway inspection to identify, document, and collect debris that could result in orbiter damage. Runway debris and any facility anomalies which cannot be removed/corrected by the Team shall be documented and photographed; the proper management authority shall be notified and corrective actions taken.

Requirements: OMRSD S00U00.050 - An engineering debris inspection team shall perform a post landing runway inspection to identify and resolve potential debris sources that may have caused vehicle damage but was not present or was not identified during pre-launch runway inspection. Obtain photographic documentation of any debris, debris sources, or flight hardware that may have been lost on landing.

Requirements: OMRSD S00U00.060 - An engineering debris inspection team shall map, document, and photograph debris-related Orbiter TPS damage and debris sources.

Requirements: OMRSD S00U00.012 - An engineering debris damage inspection team shall perform a post landing inspection of the orbiter vehicle to identify any damage caused by launch debris. Any anomalies must be documented/

photographed and coordinated with the results of the post launch shuttle/pad area debris inspection.

Requirements: OMRSD V09AJ0.095 - An engineering debris inspection team shall perform temperature measurements of RCC Nose Cap and RCC RH Wing Leading Edge Panels 9 and 17.

Documents: OMI S0026, OMI S0027, OMI S0028

Report: Briefing to NASA Convoy Commander and generate PR's. Preliminary report to Level II on the day of landing followed by a preliminary update the next day.

8) Level II report

Objective: Compile and correlate data from all inspections and analyses. Results of the debris assessment, along with recommendations for corrective actions, are presented directly to Level II via SIR and PRCB. Paper copy of complete report follows in 3 to 4 weeks. (Ref NASA Technical Memorandum series).

3.0 PRE-TEST BRIEFING

The Ice/Frost/Debris Team briefing for launch activities was conducted on 27 April 1989 at 1000 hours with the following key personnel present:

C. Stevenson	NASA - KSC	Chief, ET Mechanical Systems Lead, Ice/Debris Assess Team
G. Katnik	NASA - KSC	ET Mech/TPS, Ice/Debris Assessment, STI
S. Higginbotham	NASA - KSC	STI, Debris Assessment
B. Speece	NASA - KSC	ET Processing, Ice Assess
B. Bowen	NASA - KSC	ET Processing, "SURFICE"
P. Feamster	NASA - KSC	ET Processing, Debris Assess
J. Rivera	NASA - KSC	ET Processing, Debris Assess
A. Oliu	NASA - KSC	"SURFICE", Debris Assess
M. Bassignani	NASA - KSC	ET Processing, Ice Assess
M. Young	LSOC - SPC	ET Processing, Ice Assess
J. Cawby	LSOC - SPC	ET Processing, Ice Assess
R. Seale	LSOC - SPC	ET Processing, Ice Assess
F. Huneidi	NASA - MSFC	TPS & Ice Assessment
D. Andrews	NASA - MSFC	Debris Assessment
D. Huntsman	NASA - JSC	Level II Debris Rep
Z. Byrns	NASA - JSC	Level II Integration
C. Gray	MMC - MAF	ET TPS & Materials Design
S. Copsey	MMC - MAF	ET TPS Testing/Certif
B. Fleming	MMC - KSC	ET Processing, LSS
J. McClymonds	RI - Downey	Debris Assess, LVL II Integ
A. Fazio	RI - KSC	Debris Assessment, LSS
H. Novak	USBI - PSE	SRB Processing
H. Huppi	MTI - Utah	SRM Plant Representative
G. Meeks	NASA - SSC	STI Operations
C. Thurman	NASA - SSC	STI Operations

3.1 PRE-LAUNCH SSV/PAD DEBRIS INSPECTION

The pre-launch debris inspection of the pad and Shuttle vehicle was conducted on 27 April 1989 from 1230 - 1500 hours. The detailed walkdown of Launch Pad 39B and MLP-1 also included the primary flight elements OV-104 Atlantis (4th flight), ET-29 (LWT-22), and BIO-27. Documentary photographs were taken of facility anomalies, potential sources of vehicle damaging debris, and new vehicle configurations.

There were no major vehicle anomalies. An anomaly on the External Tank consisted of minor missing topcoat at three locations near the nosecone -Y GOX vent louver. Per schedule, the tumble valve cover had not been installed yet. This area was later checked for proper installation of the cover and removal of the GSE. Non-flight duct tape on the LH aft skirt rain shield adjacent to holddown post #6 was found and removed during the inspection. The only other vehicle concern was the lack of covers on the holddown post separation bolt firing lines on holddown posts #1, 2, 5, and 6. OMI B5306 will be changed to remove these covers later in the count.

Many bolts on MLP deck access covers had not yet been torqued: HPU access ports near the RH SRB, a plate adjacent to holddown post #3 walking beam hoist, a plate next to the ESA access port, and a deck access plate in the NE corner of the MLP.

Two PPU electrical box covers in the NW corner of the MLP deck and electrical junction box covers in both the NE and NW corners were loose. Shimming blocks in the water deluge pipe support near holddown post #4 could be rotated.

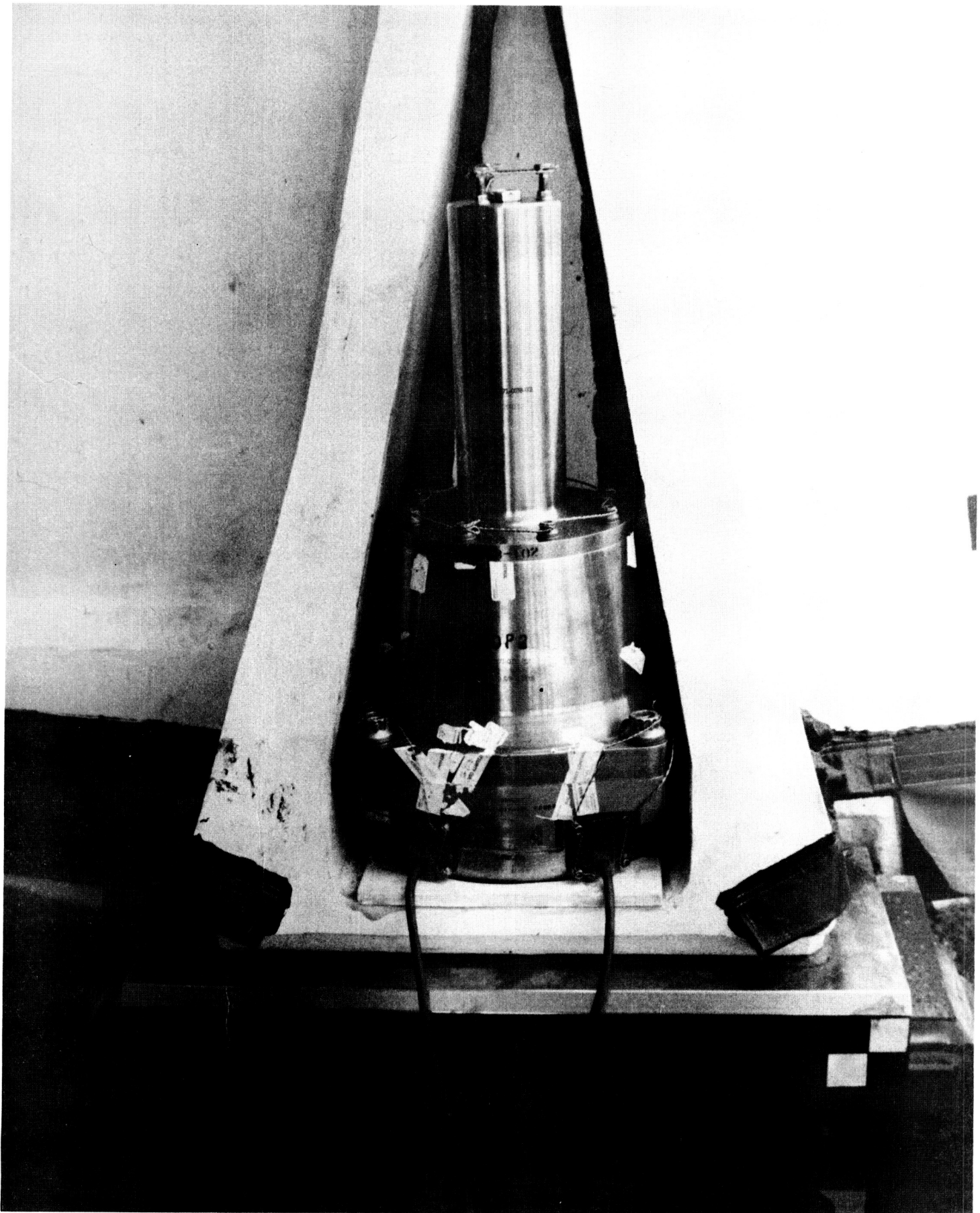
Debris was scattered in the holddown post #4 and #8 haunches. A Kellem grip anchor weight lay on the MLP deck near the LO2 TSM northeast corner. Excess cord for securing the sound suppression water troughs had not been trimmed at the MLP attach points. The OMI will be changed to trim all excess cord on future installations.

Latches on the FSS 135 foot level OIS box were loose.

Due to the unresolved problem of excessive vapor emanating from the ET/ORB LH2 umbilical interface area during the cryo-load/launch of STS-29R, a temporary hydrogen detector was installed on the ET/ORB LH2 umbilical of the STS-30R vehicle. This detector consisted of two tygon tubes that ran from the LH2 umbilical area to the hazardous gas detection equipment located on the FSS. The tubes were attached to the vehicle by three velcro strap assemblies. A length of parachute cord attached to these assemblies allowed the entire apparatus to be quickly removed from the vehicle without causing TPS damage. The hydrogen sensor was intended to remain in place during cryo loading and was removed by the Ice Inspection Team during the T-3 hour hold.

Pad Operations provided real time support for the debris inspection and most of the facility discrepancies were worked as the walkdown progressed. Cleanup of the MLP deck and pad surface was almost complete at the time of the inspection. The remaining facility discrepancies were transferred to the pad leader for resolution prior to vehicle tanking. Overall, the condition and cleanliness of the pad surface and MLP deck was excellent.

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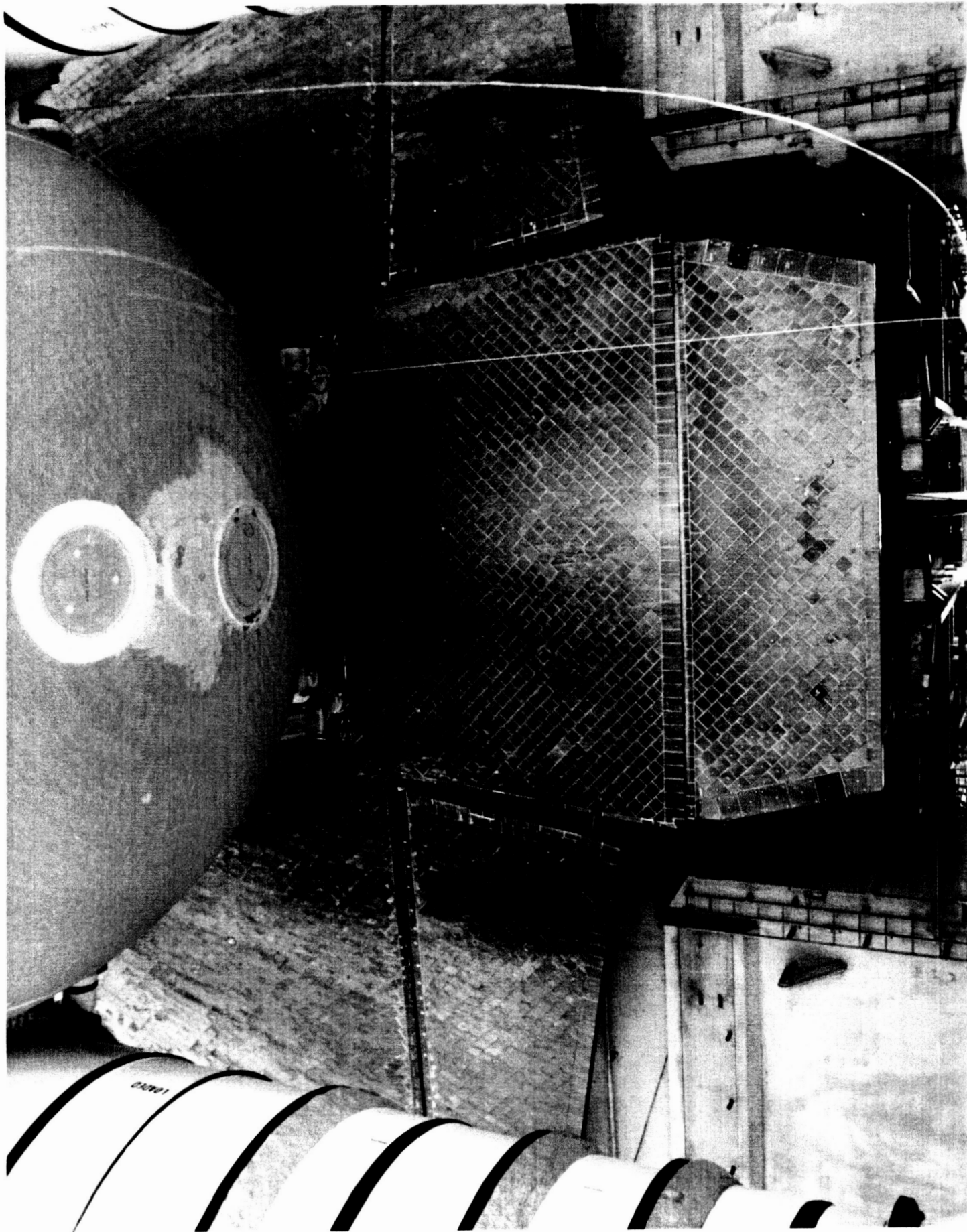


COVERS ON THE HDP SEPARATION BOLT FIRING LINES WILL
BE REMOVED LATER IN THE COUNT IN FUTURE FLOWS

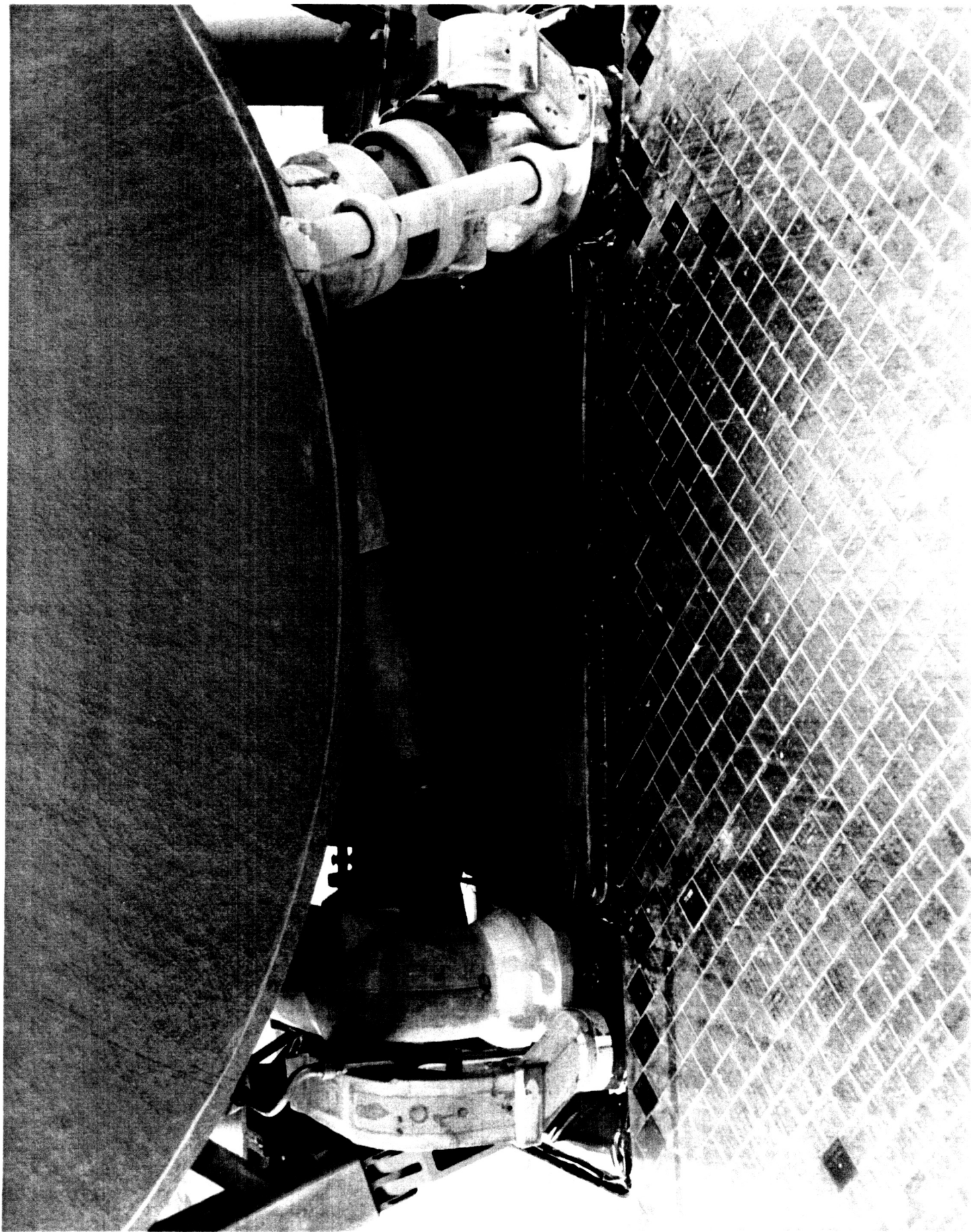
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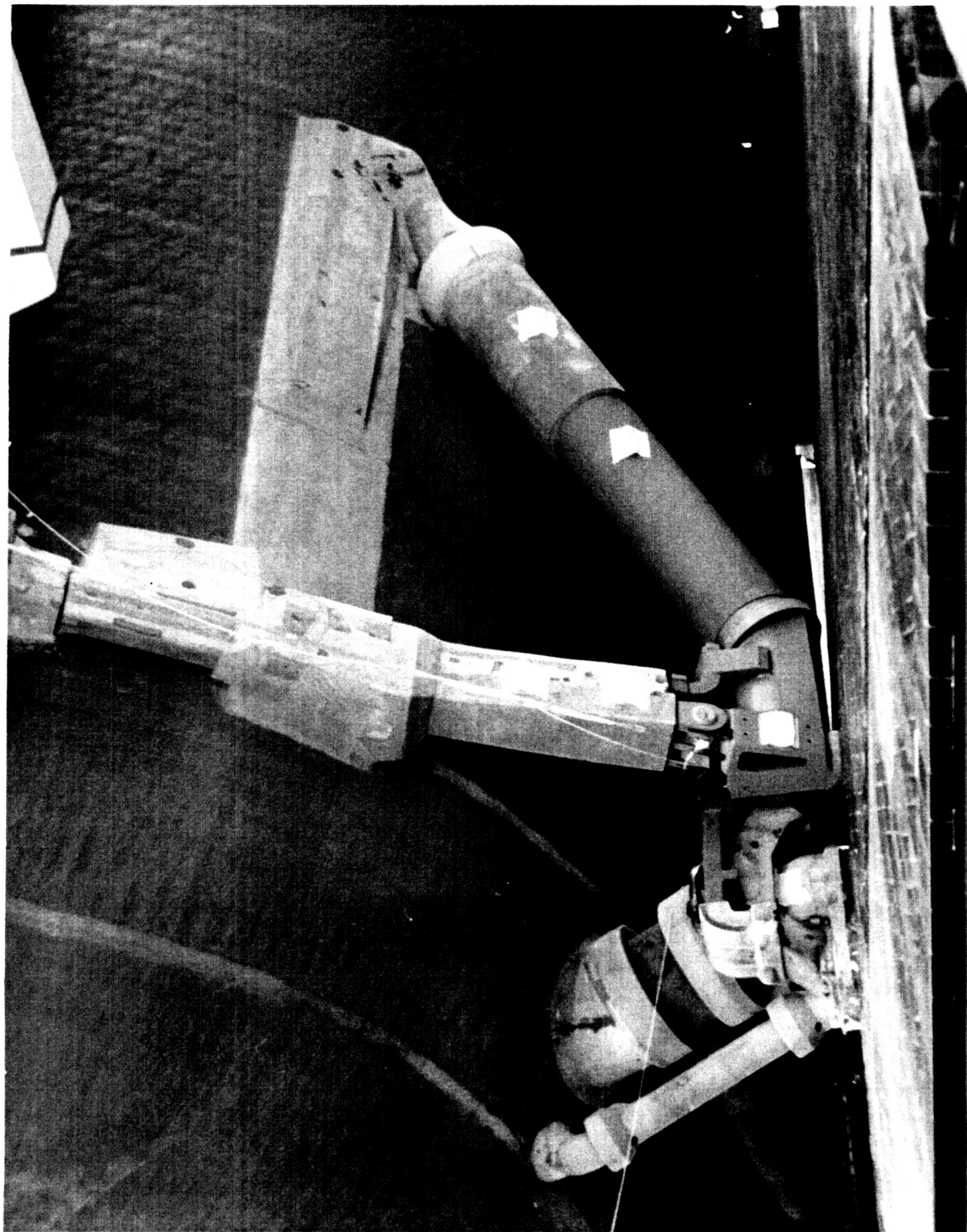
SRB AFT SKIRT INSTAFOAM SHOULD BE TRIMMED TO
ALLOW CLEARANCE AROUND HOLDDOWN POST



TYGON TUBING AND RELEASE CORD INDICATE TEMPORARY INSTALLATION
OF ET/ORB HYDROGEN UMBILICAL LEAK DETECTOR



BAGGIE CLOSEOUT ON ET/ORB UMBILICALS. HYDROGEN LEAK DETECTOR
TYGON TUBE IS VISIBLE AT LH2 UMBILICAL CABLE TRAY.



HYDROGEN DETECTOR IS TEMPORARILY ATTACHED TO ET/SRB STRUT
FAIRING, ET THRUST FITTING, AND LH2 TANK PRESS LINE

4.0 LAUNCH SCRUB

The launch attempt on 28 April 1989 was scrubbed at T-31 seconds due to a malfunction of the SSME #1 recirculation pump. An extended scrub turnaround was initiated with a new launch date set for 4 May 1989.

4.1 ICE/FROST INSPECTION

The Ice/Frost Inspection of the cryoloaded vehicle was performed on 28 April 1989 from 0845 to 1050 hours during the two hour built-in-hold at T-3 hours in the countdown. There were no violations of NSTS-08303 or the Launch Commit Criteria. Ambient weather conditions at the time of the inspection were:

Temperature:	73 F
Relative Humidity:	76 %
Wind Speed:	7 Knots
Wind Direction:	302 Degrees

The portable STI infrared scanner was utilized to obtain surface temperature measurements for an overall thermal assessment of the vehicle, as shown in Figure 1 and 2.

4.2 ORBITER OBSERVATIONS

No Orbiter tile anomalies were observed. The average Orbiter surface temperature was recorded as 72 degrees F. The surface temperatures of the SSME engine mounted heat shields were measured at 75 degrees F for SSME #1 (32 degrees F at the interface), 65 degrees F for SSME #2 (39 degrees at the interface), and 74 degrees F for SSME #3 (57 degrees at the interface). Some frost was visible on the nozzle to heatshield interface on SSME #1 and #2 with a small amount of ice on SSME #2. The heatshield on SSME #3 was clean.

4.3 SRB OBSERVATIONS

No SRB anomalies were observed. The STI portable infrared scanner recorded LH SRB surface temperatures between 69 to 74 degrees F while temperatures on the RH SRB ranged from 71 to 73 degrees F. Temperatures in the area of the SRB field joint heaters ranged from 80 to 85 degrees F. The predicted Propellant Mean Bulk Temperature (PMBT) supplied by MTI was 71 degrees F.

FIGURE 1. INFRA-RED SCANNER SSV SUMMARY DATA

TIME: 0845 - 1050

DATE: 28 April 1989

VEH. STS- 30R

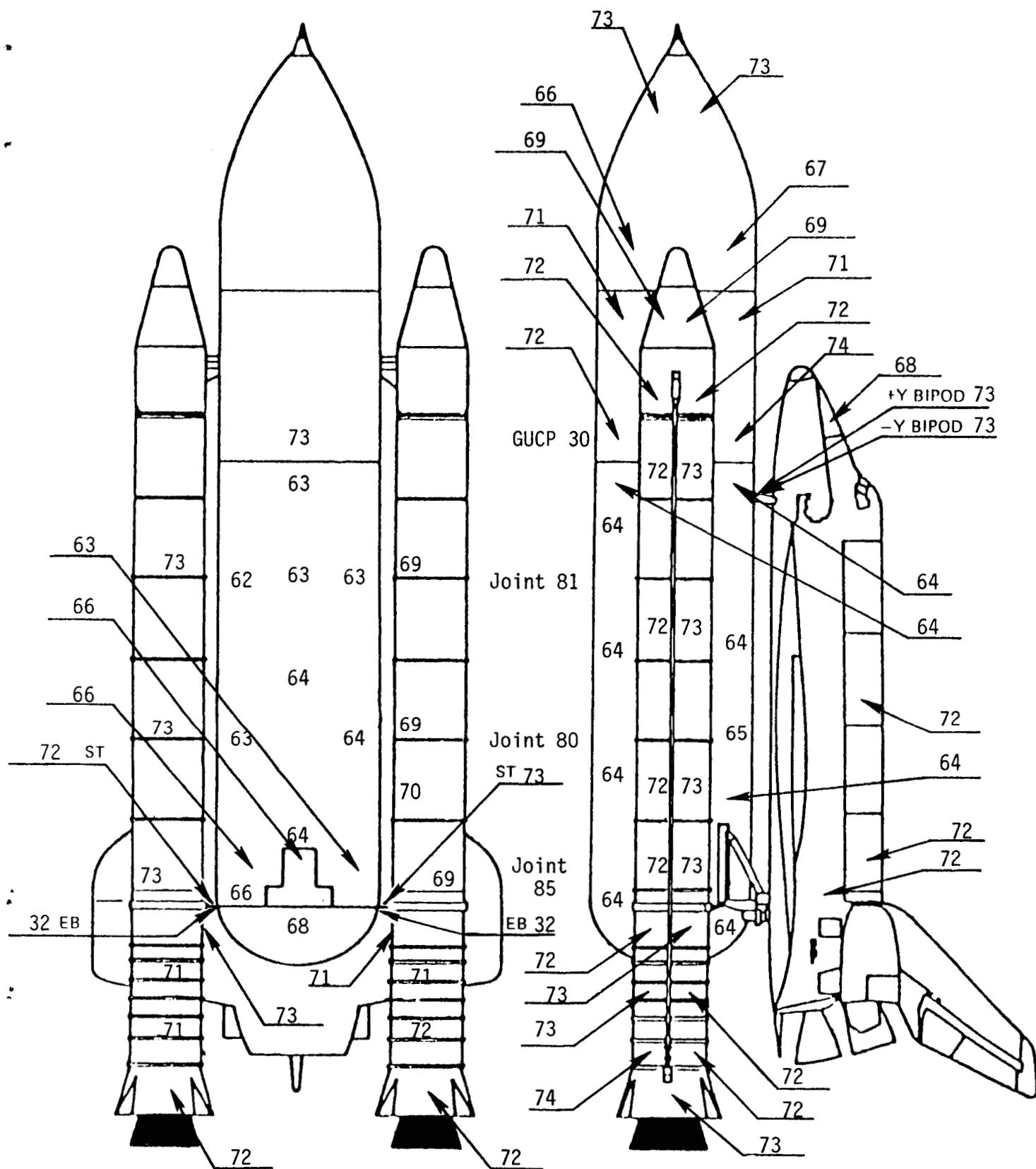
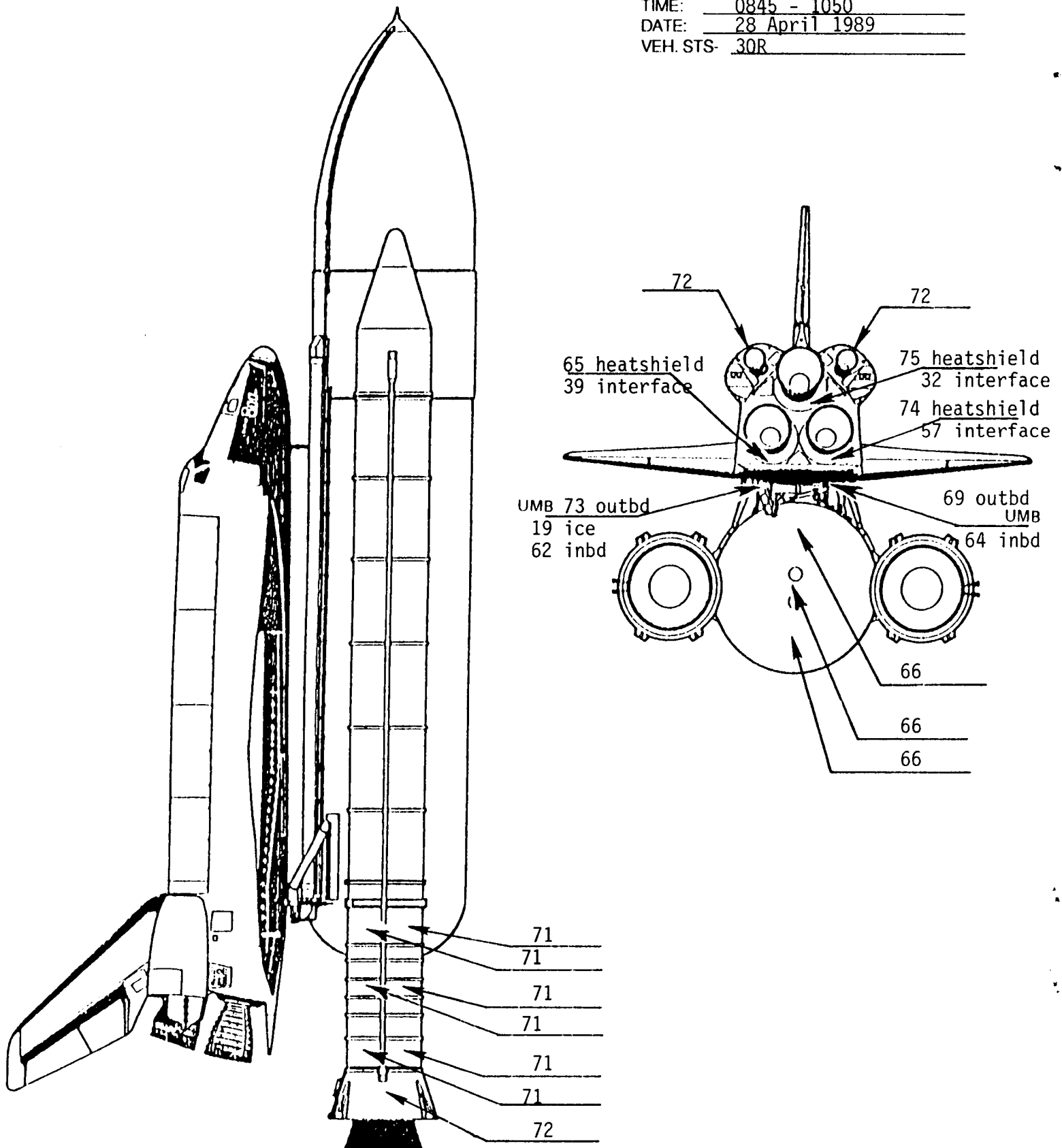


FIGURE 2. INFRA-RED SCANNER SSV SUMMARY DATA

TIME: 0845 - 1050
 DATE: 28 April 1989
 VEH. STS- 30R



4.4 EXTERNAL TANK OBSERVATIONS

The ice/frost prediction computer program was run from 0545 to 1430 hours and the results tabulated in Figures 3, 4, and 5. The program predicted condensate with no ice accumulation on all TPS acreage surfaces.

No acreage ice or frost and minimal condensate was present on the LO2 tank, Intertank, and LH2 tank. The IR scanner measured an average surface temperature of 65 degrees F on the LO2 tank, 73 degrees F on the Intertank, and 57 degrees F on the upper and lower LH2 tank.

Ice/Frost covered the lower EB fittings outboard to the strut pin hole with condensate on the rest of the fitting. The EB struts were dry and were not covered by ice.

The LH2 tank pressurization line barrymounts had small frost areas forming on the aft surface of the ramps. Ice/frost was present in all the LO2 feedline bellows and support brackets. These conditions are acceptable per NSTS-08303.

The LO2 ET/ORB umbilical exhibited ice accumulation on both the inboard and outboard sides of the baggie. Frost fingers had formed on the purge vents and normal venting was occurring. The IR scanner measured 69 degrees F on the outboard acreage and 64 degrees F on the inboard acreage of the umbilical.

Ice/frost was present in the LH2 ET/ORB recirculation line bellows, purge vents, and in an area on the aft side of the baggie. Hard ice had formed on the top, inboard, and outboard sides of the baggie but is acceptable per NSTS-08303. Venting was normal from the purge vents and no liquid cryogenic drops fell from the straws/tubes or acreage areas. The IR scanner measured 73 degrees F on the outboard acreage, except for a reading of 19 degrees on the baggie ice, and 62 degrees F on the inboard acreage of the umbilical.

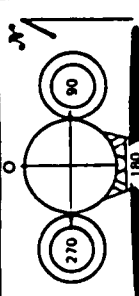
Frost had formed in two stringers at the LO2 tank to intertank flange on the -Y-Z side of the vehicle. This formation was outside the debris zone and acceptable per NSTS-08303.

The tumble valve cover was intact and not protruding.

The ET/ORB hydrogen detection sensor tygon tubing was removed with no damage to the vehicle.

After the launch was scrubbed, vapors were observed during detank operations emanating from the LH2 recirculation line burst disc area nearest the ET. The velocity and directional attitude of the vapors gave the appearance that the burst disc had ruptured. The vapors tapered off after several minutes, but reappeared when detank was complete and the recirculation line had warmed. Table 1 presents a timeline of events pertaining to

TEST:		DATE: 4/28/89										T-0 TIME: DATE:													
STS- 30R		Scrub - SSME #1 Recirculation Pump																							
ORBITER	ET	SRB	MLP	PAO	LO2					LM2															
OV- 104	29	B1027	1	39B	LO2 TANK STA 370 TO 540					LO2 TANK STA 550 TO 852					LM2 TANK STA 1130 TO 1380					LM2 TANK STA 1380 TO 2058					
CONDITIONS																									
LOCAL TIME	TEMP. of	REL HUM. %	DEW PT of	WIND KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFT TEMP of	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFT TEMP of	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFT TEMP of	COND RATE IN/HR	ICE RATE IN/HR					
0545	64.0	98	63.44	6	283	II	3.54	54.54	+0029	1002	II	3.54	48.66	+0043	0712	II	2.50	43.66	+0043	0407	II	7.26	54.26	+0055	1594
0600	63.9	99	63.62	7	267	II	4.13	55.54	+0031	1162	II	4.13	50.29	+0046	0871	II	3.01	45.62	+0044	0523	II	8.47	55.45	+0058	1899
0615	64.1	99	63.82	6	269	II	3.54	54.84	+0030	1018	II	3.54	48.98	+0044	0735	II	2.58	43.98	+0041	0419	II	7.26	54.57	+0056	1621
0630	64.0	99	63.72	7	259	II	4.13	55.85	+0034	1168	II	4.13	50.41	+0046	0877	II	3.01	45.75	+0044	0528	II	8.47	55.57	+0058	1911
0645	64.6	99	64.32	7	272	II	4.13	56.34	+0032	1289	II	4.13	51.13	+0046	0916	II	3.01	46.50	+0044	0560	II	8.47	56.25	+0058	1978
0700	64.8	99	64.52	8	280	II	4.72	57.32	+0032	1382	II	4.72	52.62	+0048	1086	II	3.44	48.32	+0047	0687	II	9.68	57.34	+0059	2308
0715	64.8	100	64.80	8	270	II	4.72	57.51	+0033	1395	II	4.72	52.82	+0049	1098	II	3.44	48.52	+0047	0697	II	9.68	57.54	+0061	2330
0730	65.7	100	65.70	7	281	II	4.13	57.80	+0033	1296	II	4.13	52.67	+0048	1001	II	3.01	48.09	+0046	0628	II	8.47	57.71	+0061	2122
0745	66.4	100	66.40	9	275	II	5.31	59.92	+0035	1687	II	5.31	55.75	+0052	1383	II	3.87	51.80	+0051	0916	II	10.89	60.02	+0064	2865
0800	66.6	100	66.60	7	273	II	4.13	58.83	+0033	1360	II	4.13	53.76	+0049	1062	II	3.01	49.23	+0047	0678	II	8.47	58.74	+0062	2227
0815	66.8	99	66.52	11	277	II	6.49	61.10	+0036	2045	II	6.49	57.56	+0054	1735	II	4.73	54.10	+0054	1179	II	13.31	61.28	+0064	3554
0830	67.3	99	67.02	8	270	II	4.72	60.15	+0034	1574	II	4.72	55.61	+0051	1271	II	3.44	51.44	+0049	0836	II	9.68	60.16	+0062	2629
0845	67.5	98	66.93	9	287	II	5.31	60.77	+0034	1750	II	5.31	56.63	+0052	1445	II	3.87	52.75	+0051	0966	II	10.89	60.84	+0062	2969
0900	68.5	97	67.64	7	296	II	4.13	60.41	+0032	1458	II	4.13	55.44	+0049	1158	II	3.22	51.80	+0048	0821	II	8.61	60.38	+0060	2427
0915	70.1	92	67.75	10	311	II	5.90	62.89	+0031	2059	II	5.90	59.18	+0050	1748	II	4.60	56.31	+0051	1293	II	12.30	63.02	+0057	3587



ECG-30

Figure 3. Ice/Frost Computer Predictions

STS- 30R		TEST: Scrub - SSME #1 Recirculation Pump										DATE: 4/28/89		1-TIME: DATE:											
ORBITER	EV	SRB	MLP	F4D	LO ₂		39B		LO ₂		LM ₂		FAST FILL TIME: 0615		CHILLDOWN TIME: 0539		SLOW FILL TIME: 0827		REPLENISH TIME: 0827						
OV- 104	29	B1027	1																						
CONDITIONS																									
LOCAL TIME	TEMP. °F	REL. HUM. %	DEW PT. °F	WIND VEL. KNTS	WIND DIR DEG	REGION	LOCAL VEL. KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL. KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL. KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR					
0930	70.8	89	67.51	6	302	II	3.54	50.53	+.0027	1328	II	3.54	55.04	+.0043	1031	II	2.76	51.20	+.0043	0727	II	7.38	60.21	0052	2145
0945	71.0	85	66.42	11	311	II	6.49	52.74	+.0024	2187	II	6.49	59.29	+.0044	1875	II	5.06	56.63	+.0046	1397	II	13.53	62.83	0046	3839
1000	72.4	81	66.45	8	314	II	4.72	51.99	+.0022	1697	II	4.72	57.58	+.0040	1394	II	3.68	54.40	+.0042	1020	II	9.84	61.84	0043	2855
1015	73.6	78	66.58	8	304	II	4.72	52.58	+.0020	1739	II	4.72	58.22	+.0038	1435	II	3.68	55.09	+.0046	1056	II	9.84	62.39	0039	2920
1030	75.2	70	65.12	8	300	II	4.72	52.33	+.0014	1718	II	4.72	57.97	+.0032	1417	II	3.68	54.95	+.0037	1046	II	9.84	62.02	0028	2869
1045	75.7	66	63.96	8	281	II	4.72	51.83	+.0010	1681	II	4.72	57.46	+.0028	1381	II	3.44	53.82	+.0031	0947	II	9.68	61.38	0023	2753
1100	76.8	60	62.38	6	307	II	3.54	50.12	+.0008	1297	II	3.54	54.73	+.0024	1008	II	2.76	51.28	+.0026	0725	II	7.38	59.30	0020	2045
1115	78.0	59	63.07	6	304	II	3.54	51.08	+.0007	1352	II	3.54	55.77	+.0023	1061	II	2.76	52.37	+.0026	0772	II	7.38	60.24	0019	2132
1130	78.3	57	62.40	4	256	II	2.36	58.92	+.0009	0973	II	2.36	51.90	+.0022	0692	II	1.72	48.26	+.0024	0609	II	4.84	57.11	0023	1377
1145	79.2	53	61.25	6	259	II	3.54	50.62	+.0002	1323	II	3.54	55.29	+.0018	1035	II	2.58	51.32	+.0022	0700	II	7.26	59.54	0011	2039
1200	80.0	50	60.41	6	243	II	3.54	50.61	+.0000	1317	II	3.54	55.21	+.0016	1030	II	1.92	48.44	+.0019	0614	II	8.16	60.04	0002	2270
1215	81.1	47	59.75	4	317	II	2.36	58.96	+.0002	0972	II	2.36	52.02	+.0015	0695	II	1.84	48.87	+.0018	0631	II	4.92	57.01	0011	1381
1230	81.2	44	58.02	3	71	II	1.77	56.78	+.0002	0887	II	1.77	49.43	+.0014	0648	II	1.65	48.15	+.0016	0599	II	3.66	53.82	0012	0976
1245	79.3	55	62.38	8	79	I	4.72	52.51	+.0000	1720	II	4.72	58.18	+.0018	1423	II	4.40	56.82	+.0022	1277	II	9.76	61.84	0004	2817
1300	80.0	55	63.06	4	98	II	2.95	51.20	+.0006	1218	II	2.95	55.25	+.0021	0930	II	2.75	53.44	+.0024	0816	II	6.10	59.92	0017	1831

12/2/89-330

Figure 4. Ice/Frost Computer Predictions

STS- 30R		TEST: Scrub - SSME #1 Recirculation Pump										DATE: 4/28/89		1-0 TIME: DATE:	
ORBITER	LT	SRB	MLP	PAD	LO ₂	CHILLDOWN TIME: 0550	FAST FILL TIME: 0624	LM ₂	CHILLDOWN TIME: 0539	FAST FILL TIME: 0615					
OV- 104	29	B1027	1	39B		SLOW FILL TIME: 0614 <td>REPLENISH TIME: 0826<td></td><td>SLOW FILL TIME: 0547<td>REPLENISH TIME: 0827<th data-cs="5" data-kind="parent"></th><th data-kind="ghost"></th><th data-kind="ghost"></th><th data-kind="ghost"></th><th data-kind="ghost"></th></td></td></td>	REPLENISH TIME: 0826 <td></td> <td>SLOW FILL TIME: 0547<td>REPLENISH TIME: 0827<th data-cs="5" data-kind="parent"></th><th data-kind="ghost"></th><th data-kind="ghost"></th><th data-kind="ghost"></th><th data-kind="ghost"></th></td></td>		SLOW FILL TIME: 0547 <td>REPLENISH TIME: 0827<th data-cs="5" data-kind="parent"></th><th data-kind="ghost"></th><th data-kind="ghost"></th><th data-kind="ghost"></th><th data-kind="ghost"></th></td>	REPLENISH TIME: 0827 <th data-cs="5" data-kind="parent"></th> <th data-kind="ghost"></th> <th data-kind="ghost"></th> <th data-kind="ghost"></th> <th data-kind="ghost"></th>					
LOCAL TIME	CONDITIONS										LO ₂ TANK STA 370 TO 540				
	TEMP. of	REL HUM. %	DEW PT of	WIND VEL KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP of	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP of	COND RATE IN/HR	ICE RATE IN/HR
LO ₂ TANK STA 550 TO E52															
LM ₂ TANK STA 1130 TO 1380															
LM ₂ TANK STA 1380 TO 2058															
1315	79.8	55	62.86	6	120	II	3.54	61.81	0004	1392	II	3.54	56.54	0020	1101
1330	81.5	53	63.48	6	107	II	3.54	62.94	0002	1458	II	3.54	57.75	0019	1165
1345	78.4	60	63.93	12	126	I	7.08	64.97	0000	2477	II	7.08	61.27	0017	2164
1400	81.4	57	65.41	7	113	II	4.13	64.64	0003	1722	II	4.13	60.06	0022	1422
1415	83.2	52	64.59	9	172	I	5.31	67.31	0000	2127	II	5.31	62.03	0013	1820
1430	85.7	41	60.36	10	218	I	5.90	70.13	0000	2189	II	5.90	62.31	0011	1887
AVG.	73.10	76	64.23	7	*			60.51					55.41		
* Winds from W until 1245, then from E until 1430, then from S.															

Figure 5. ICe/Frost Computer Predictions

this anomaly, which was documented on IPR 30RV-0260. The recirculation line was removed and replaced during post drain turnaround operations.

TABLE 1. SEQUENCE OF EVENTS LEADING TO SCRUB AND APPEARANCE OF LH2 RECIRCULATION LINE VAPORS

TIME (GMT)	EVENT
118:10:42:19	LH2 RECIRC PUMP ACTIVATION
118:18:27:07	ET VENT VALVE CLOSED
118:18:27:17	ET LH2 PREPRESS BEGINS
118:18:27:27	PRESSURE STABILIZES
118:18:27:28	E2-E3 ENGINES READY
118:18:27:29	E1 ENGINE READY
118:18:28:01.739	+20 AMPS E1 RECIRC PUMP PHASE RPM DECAY (11,000-0)
118:18:28:02	RSLS FLAG
118:18:28:03.967	E1 LPFP DISCH PRESS FID, MCF LOST ENGINE READY
118:18:28:06	E1 LPFT DISCH TEMP STARTS TO RISE FROM 39 DEGREES R.
118:18:28:21	E1 LPFT DISCH TEMP PEAKS AT 41.4 DEGREES R., BEGINS TO DROP
118:18:28:29	HOLD AT T-31 SECONDS
118:18:29:52	ET LH2 VENT VALVE OPEN
118:18:29:54	E1 RECIRC PUMP RPM SPEED-UP 0-14,000 RPM
118:18:30:00	ET LH2 ULLAGE PRESS TO 15 PSIA
118:18:30.13	E2 & E3 RECIRC PUMP POWER OFF
118:18:31:49	RECIRC VLV CLOSED
118:18:44:50	FIRST VAPOR AT RECIRC LINE BELLOWS
118:18:45:06	VAPORS APPEAR AT RECIRC LINE BELLOWS
118:18:47:41	VAPOR JET APPEARS AT RECIRC LINE BURST DISC
118:18:50:35	VAPOR JET STOPS AT BURST DISC
118:18:50:42	VAPORS STOP AT BELLOWS
118:22:00:00	LH2 ECO SENSORS DRY
118:22:10:28	VAPOR RESUMES AT BELLOWS
118:22:11:06	VAPOR RESUMES AT BURST DISC
118:22:28:06	LAST VAPORS FROM BELLOWS
118:22:30:22	LAST VAPORS FROM BURST DISC

The defective recirculation line was returned to the vendor (Arrowhead, Calif.) for failure analysis. When the argon-filled bellows cavity was opened, the argon gas charge was still present. No anomalies were found with the bellows by the vendor. Subsequent LH2 cryogenic flow testing on the line was performed at MSFC and indicated liquid air cryopumping through the SLA material could occur. A 1/2 inch circumferential crack

was discovered through the SOFI adjacent to the burst disc which could produce liquid air and some vapor. However, neither the vapor volume, flow rate, or pressure to match that observed during the hold/detank could be duplicated.

The scrub summary of ice/frost team observation anomalies consists of 13 OTV recorded items:

Anomaly 001 documented vapors emanating from the ET L02 feedline bellows at stations XT-1980 and 2058. These vapors, which occur on every cryoloading, are caused by air convective cooling on the cold bellows surfaces. There were no ice/frost debris concerns.

The -Y side GOX vent seal (Anomaly 002) was folded over. Continuous observations by OTV and the Ice Team inspection showed no indications of leakage or seal fretting (Ref OMRSD S00FBO.350).

Vapors appeared to emanate from the top side of the ET/ORB LH2 umbilical and were recorded on Anomaly 003. The vapors, which were observed by the Ice Inspection Team, were venting normally from all 5 umbilical vents/tubes.

Anomaly 004 documented a piece of paper falling into the GUCP FOV, hanging up briefly on the ET GH2 vent line, and then falling out of view. This was not a debris concern and had no effect on flight hardware.

Frost had formed on the outboard +Y side of the ET/ORB L02 umbilical (Anomaly 005). This condition is acceptable per NSTS 08303.

The formation of ice/frost on the -Y side of the ET/ORB LH2 umbilical was recorded on Anomaly 006. This formation was within the established data base from previous launches and acceptable per NSTS-08303.

Anomaly 007 documented ice/frost in the L02 feedline support bracket at station XT-1860, an acceptable condition per NSTS 08303.

Ice/frost formed inboard of L02 feedline bracket (Anomaly 008) at station XT-1150. This formation is acceptable per the ice criteria.

The presence of ice/frost on two stringers (-Y-Z side) at the intertank to L02 tank interface was recorded on Anomaly 009 and found acceptable per NSTS-08303.

Anomaly 010 documented vapors and ice/frost formation on the +Y side upper corner of the ET/ORB L02 umbilical. This phenomenon is within the established data base and acceptable per NSTS 08303.

Light ice/frost formed on all LO2 feedline support brackets (Anomaly 011), and is permissible per NSTS-08303.

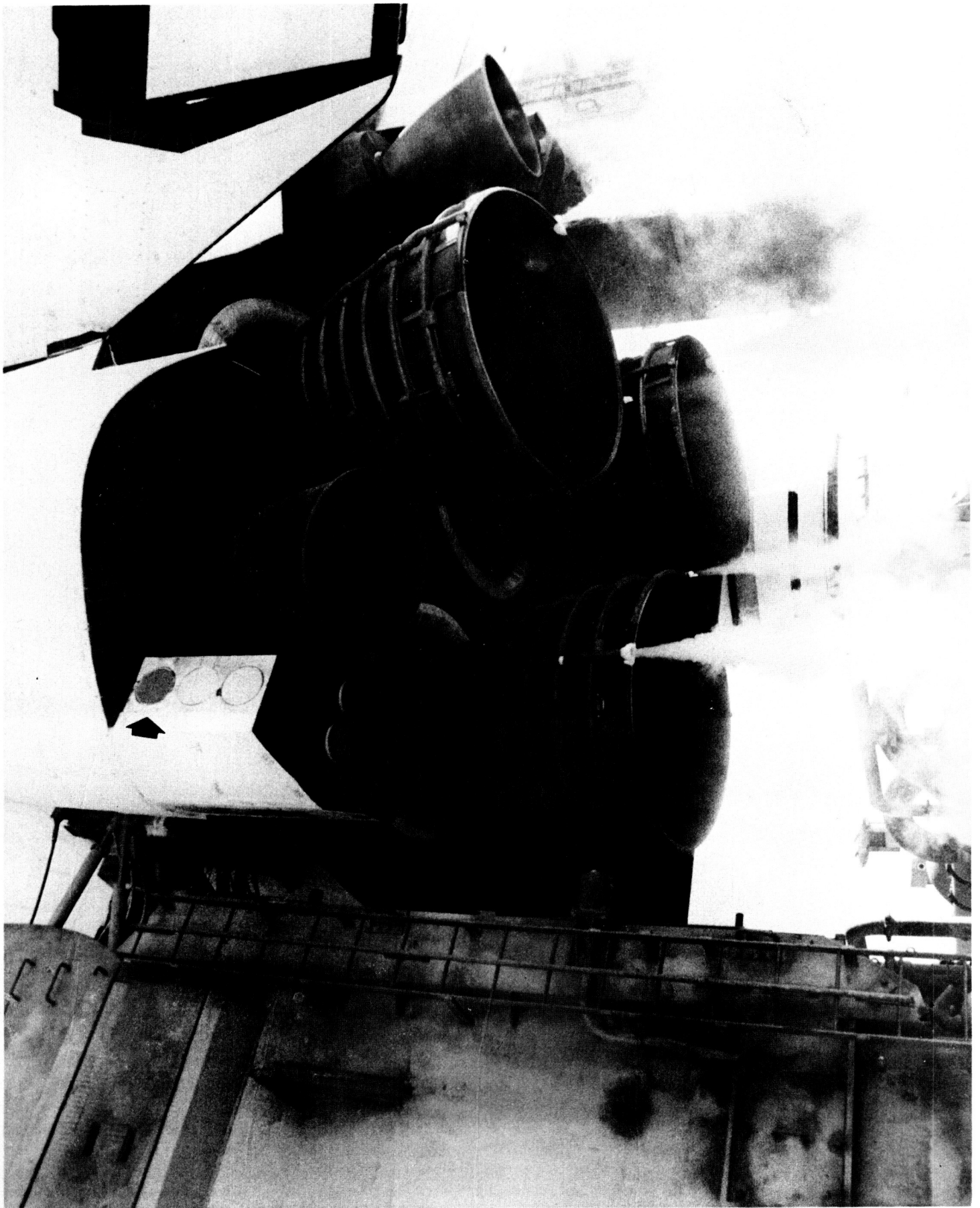
Anomaly 012 documented the darkening of the butcher paper cover on one of the Orbiter left hand aft +Z firing RCS thrusters. This discoloration was most likely due to a small oxidizer vapor leak. Minor leakage is an expected and acceptable occurrence.

The vapors from the LH2 recirculation line noted shortly after the initiation of LH2 tank drain were documented on Anomaly 013. An IPR was written on this anomaly which was later upgraded to a PR.

4.5 FACILITY OBSERVATIONS

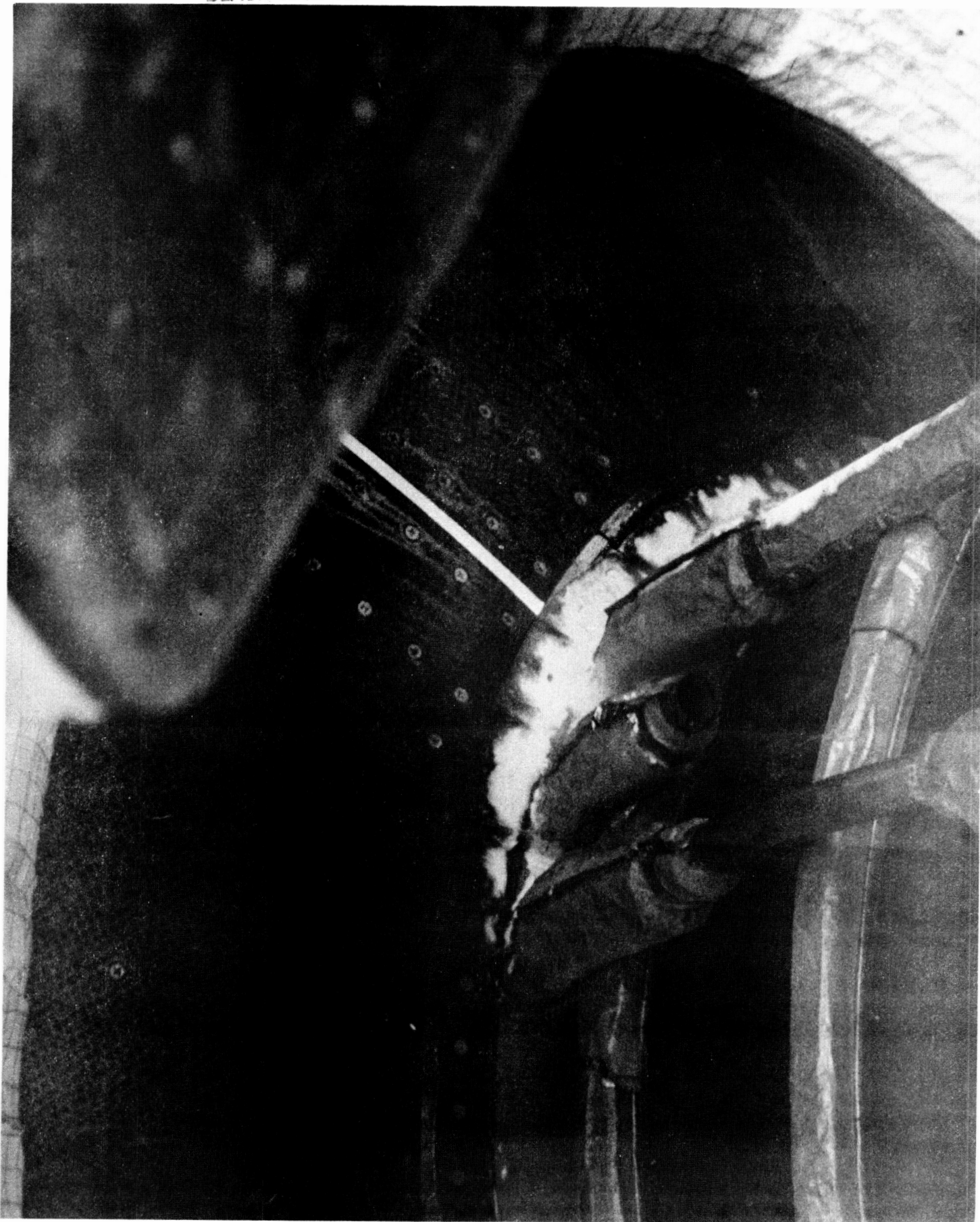
All debris concerns previously identified had been resolved prior to cryoloading and no new items were noted during the walkdown. No leaks were observed on either the LO2 or LH2 ORB T-0 umbilicals. There was also no apparent leakage anywhere on the GH2 vent line or GUCP. The modification to the GH2 vent line prevented ice from forming but some frost, which was expected, had accumulated on the GUCP legs. Visual and infrared observations of the GOX seals confirmed no leakage. The ends of the GOX vent ducts exhibited no icicles.

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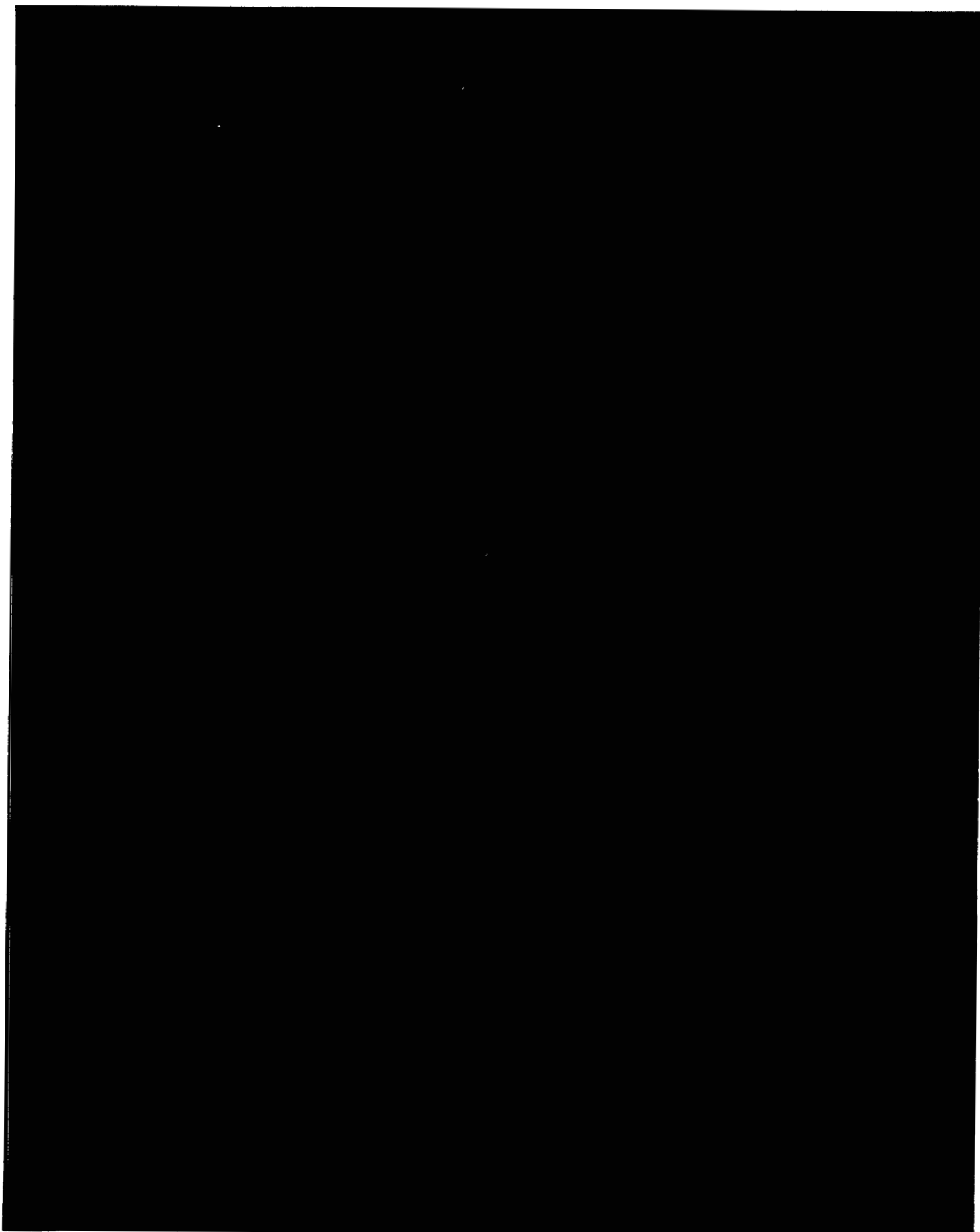


OVERALL VIEW OF SSME'S. NOTE DISCOLORED
PAPER COVER ON LH RCS STINGER.

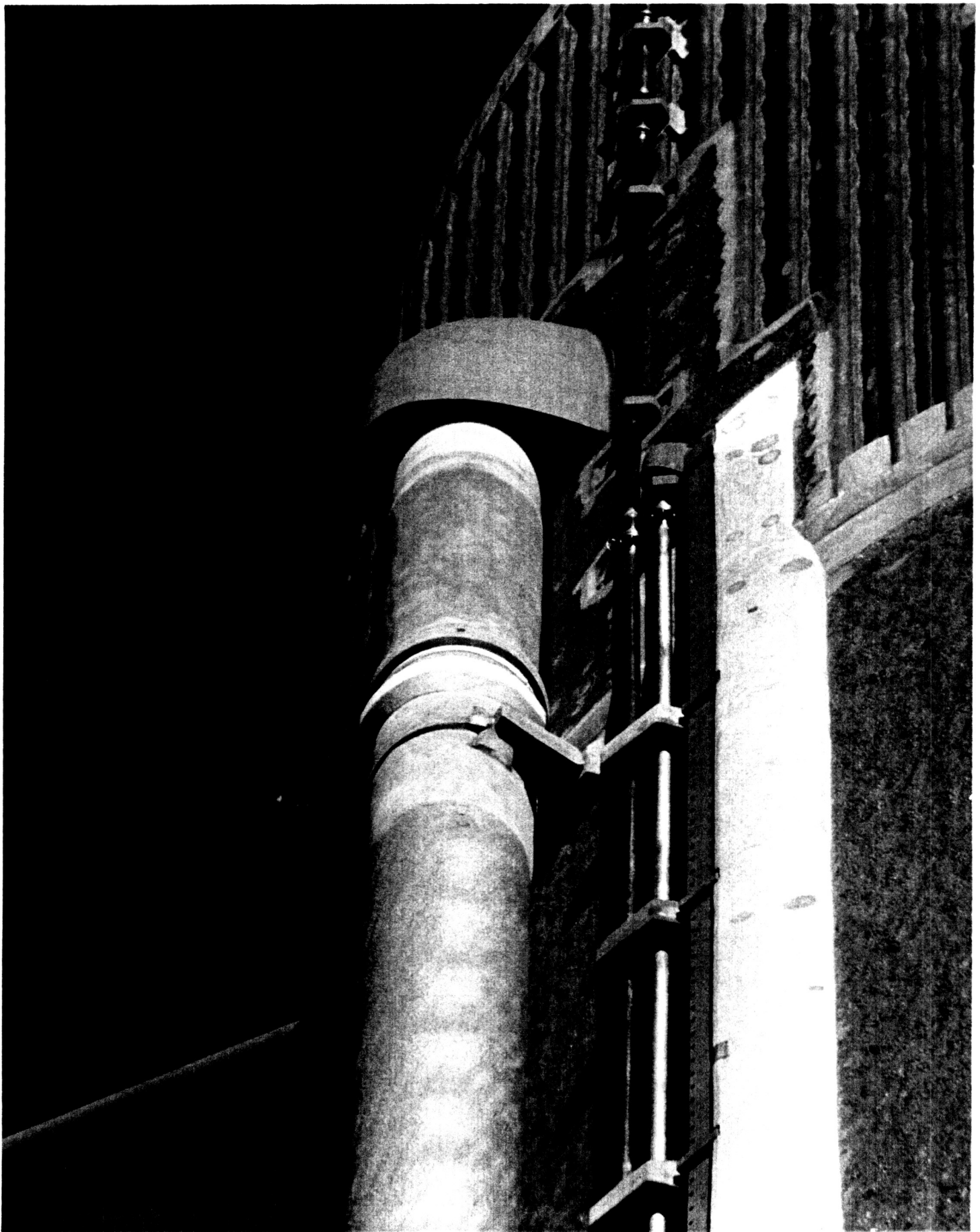
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BLACK AND WHITE PHOTOGRAPH



ICE/FROST ACCUMULATION AT ENGINE MOUNTED HEAT SHIELD
TO NOZZLE INTERFACE. CONDENSATE IS ALSO VISIBLE.



FROST AREAS ON STRINGER AT LO2 TANK TO INTERTANK
FLANGE ON THE VEHICLE -Y-Z SIDE



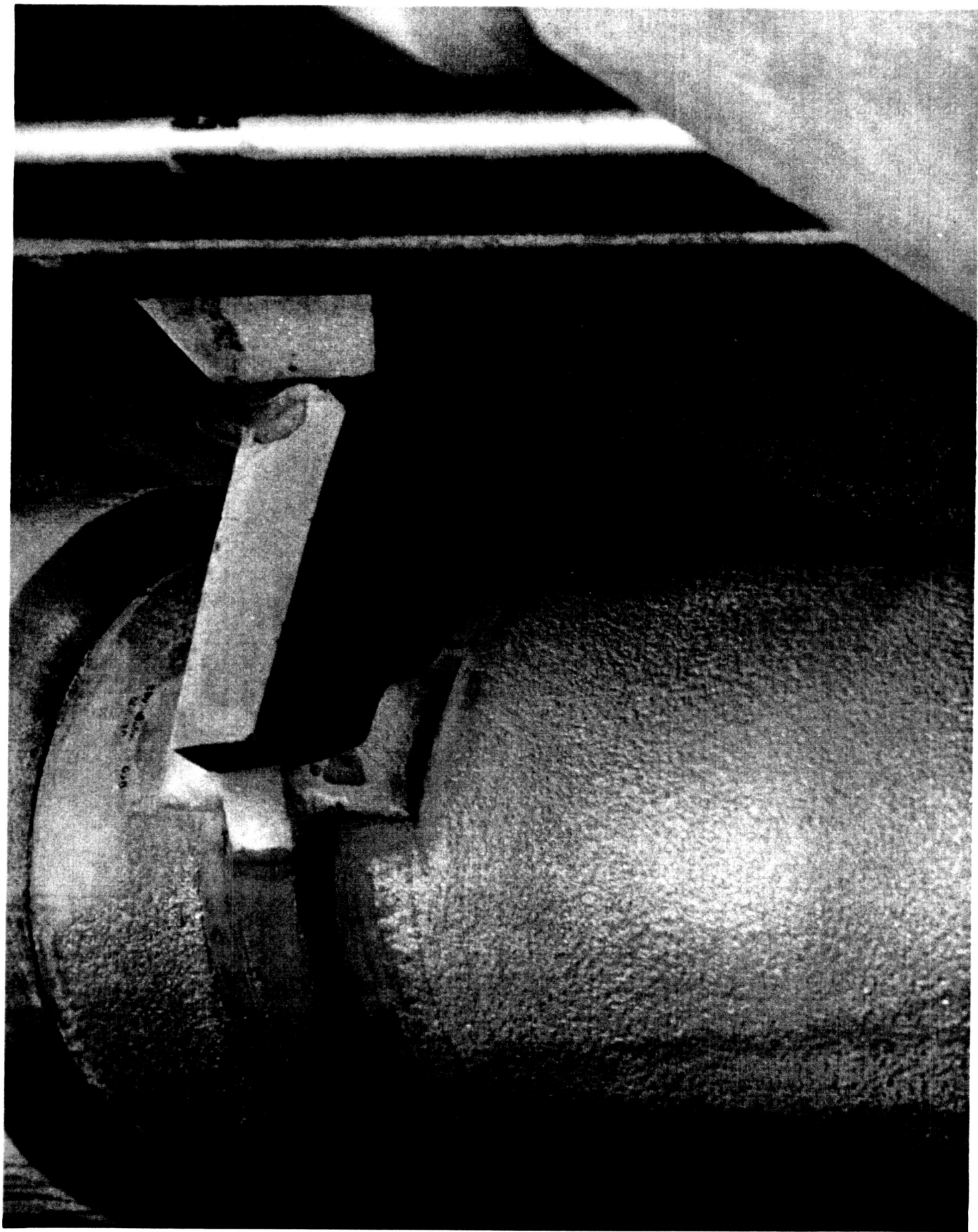
TYPICAL ICE/FROST ACCUMULATION IN
LO2 FEEDLINE BELLOWS AT XT 1106

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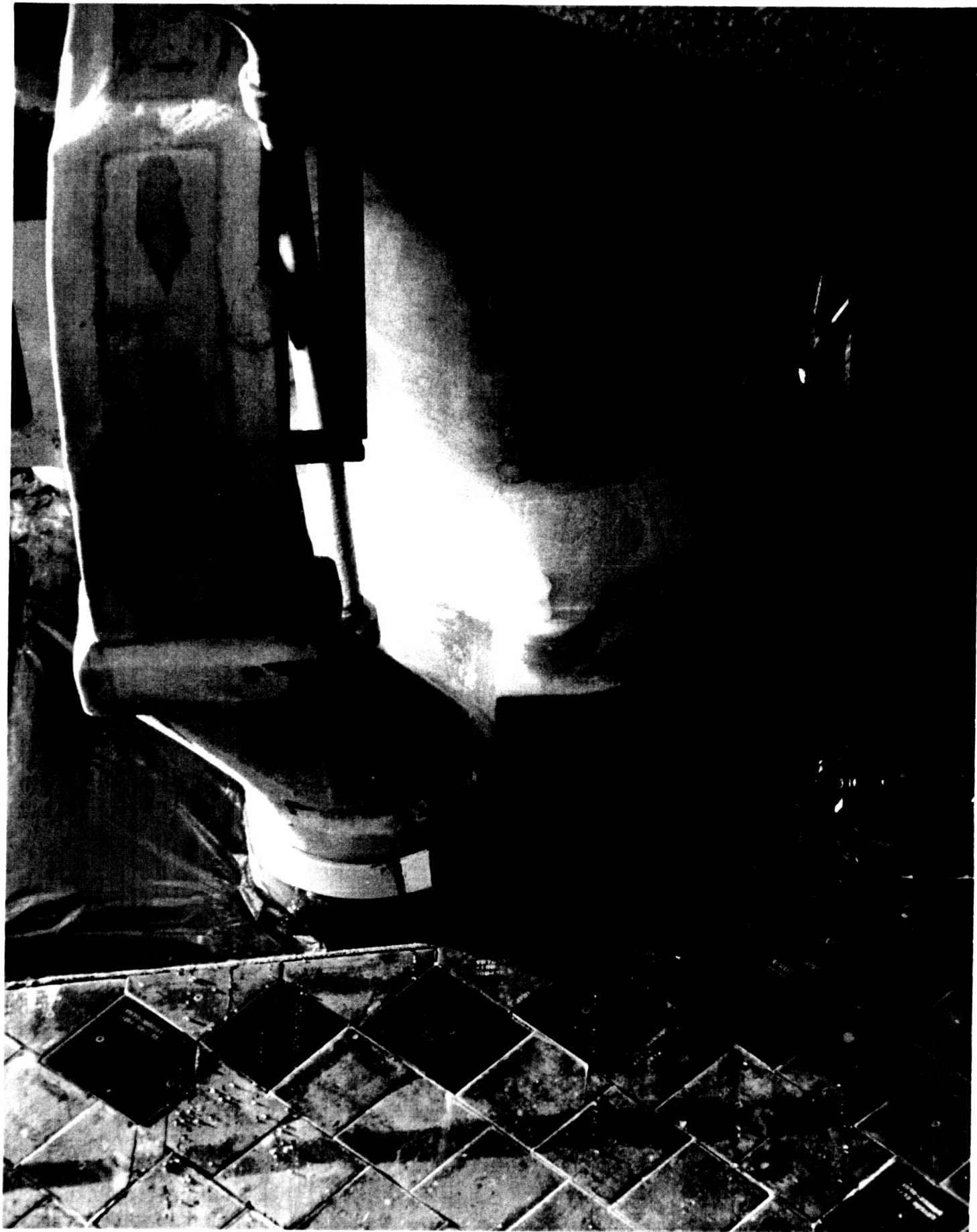
TYPICAL ICE/FROST ACCUMULATION IN LO2
FEEDLINE SUPPORT BRACKET AT XT 1871



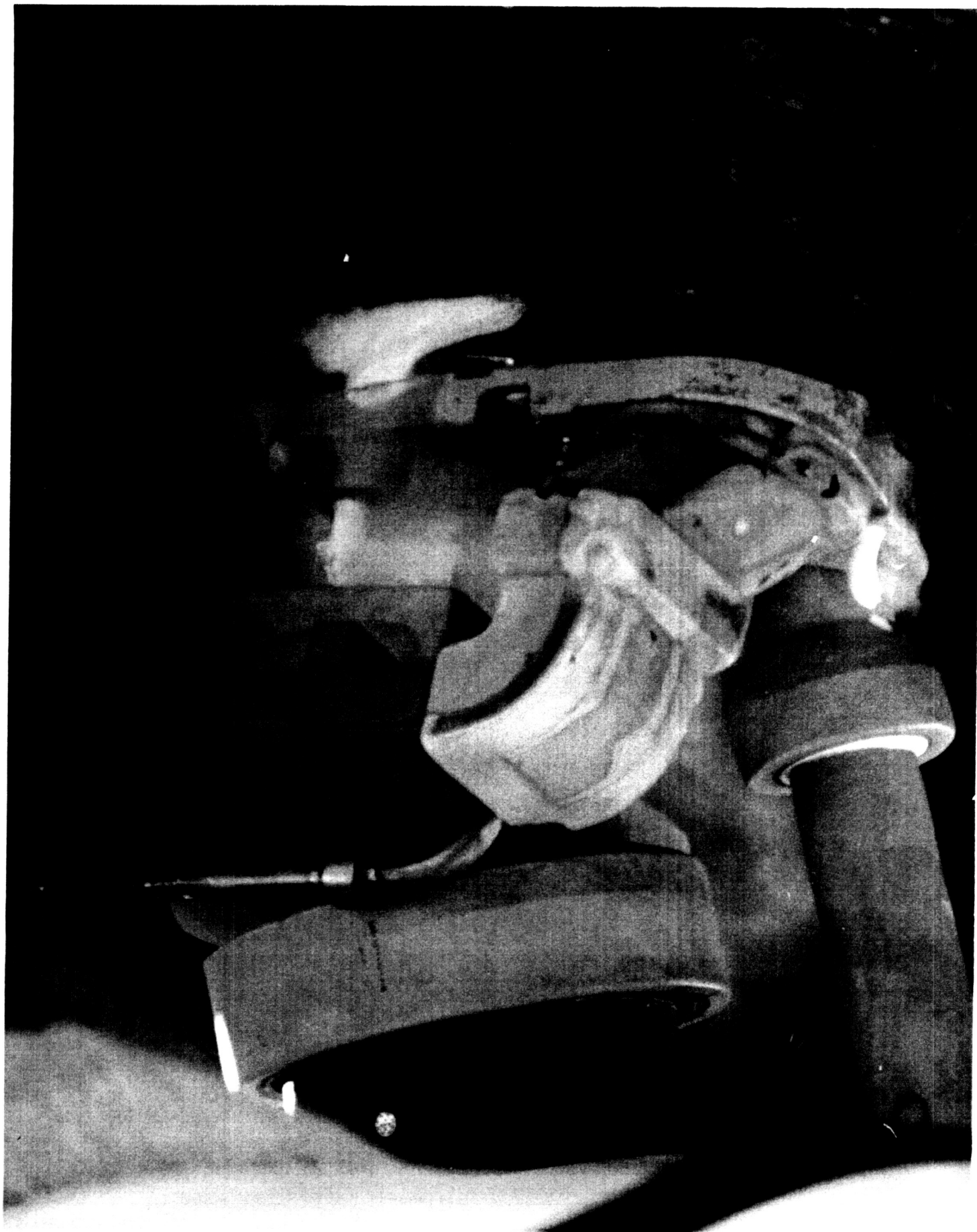
HARD ICE AND FROST ACCUMULATION IN
LO2 FEEDLINE BELLOWS AT XT 1973



ET/ORB LO2 UMBILICAL EXHIBITING FROST FINGER ON
PURGE VENT AND ICE ACCUMULATION ON BAGGIE



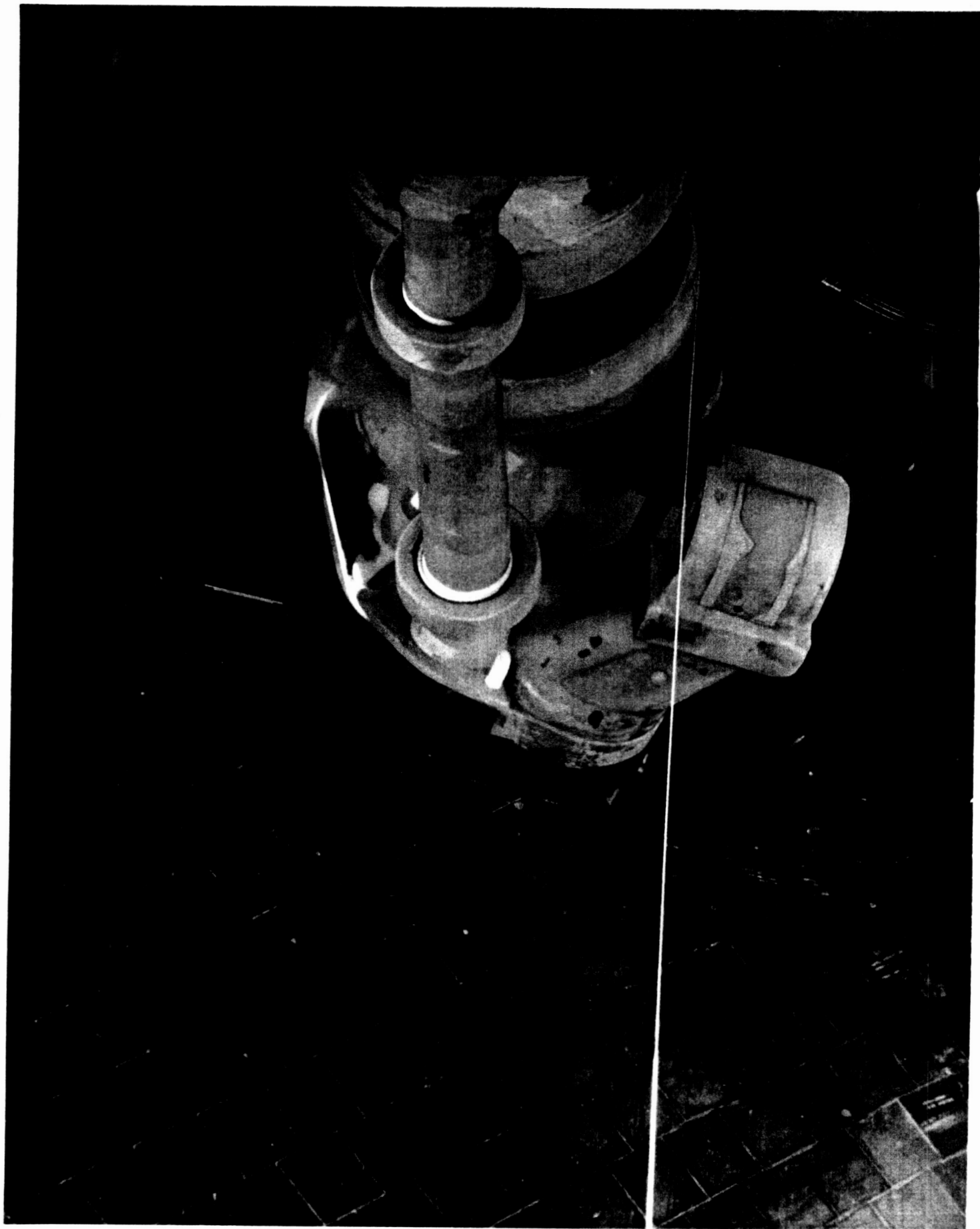
ET/ORB LO2 UMBILICAL EXHIBITING FROST FINGERS ON PURGE
VENTS AND ICE ACCUMULATION ON INBOARD SIDE OF BAGGIE



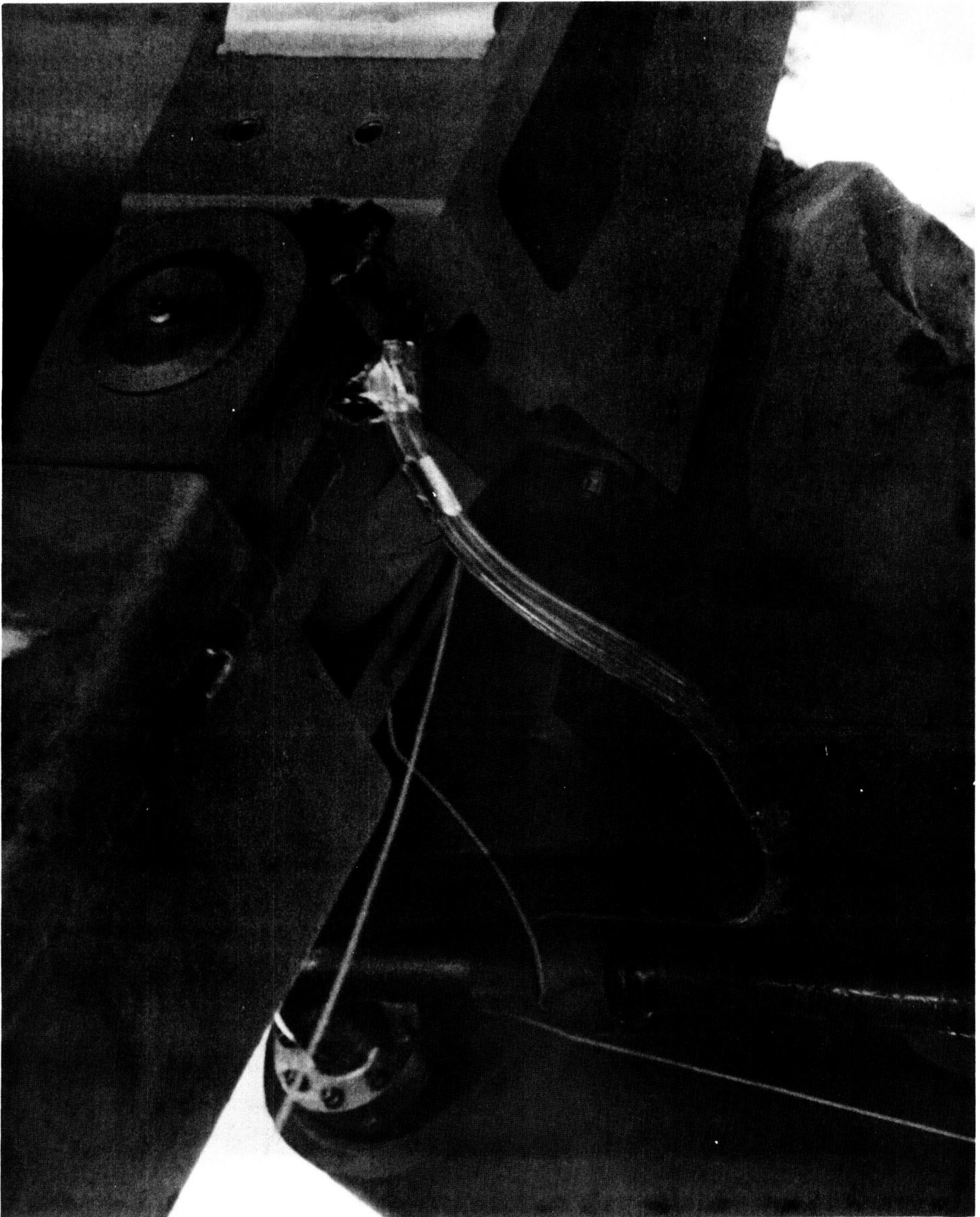
TYPICAL FROST FINGERS ON PURGE VENTS AND LESS THAN USUAL
ICE ACCUMULATION ON ET/ORB LH2 UMBILICAL BAGGIE



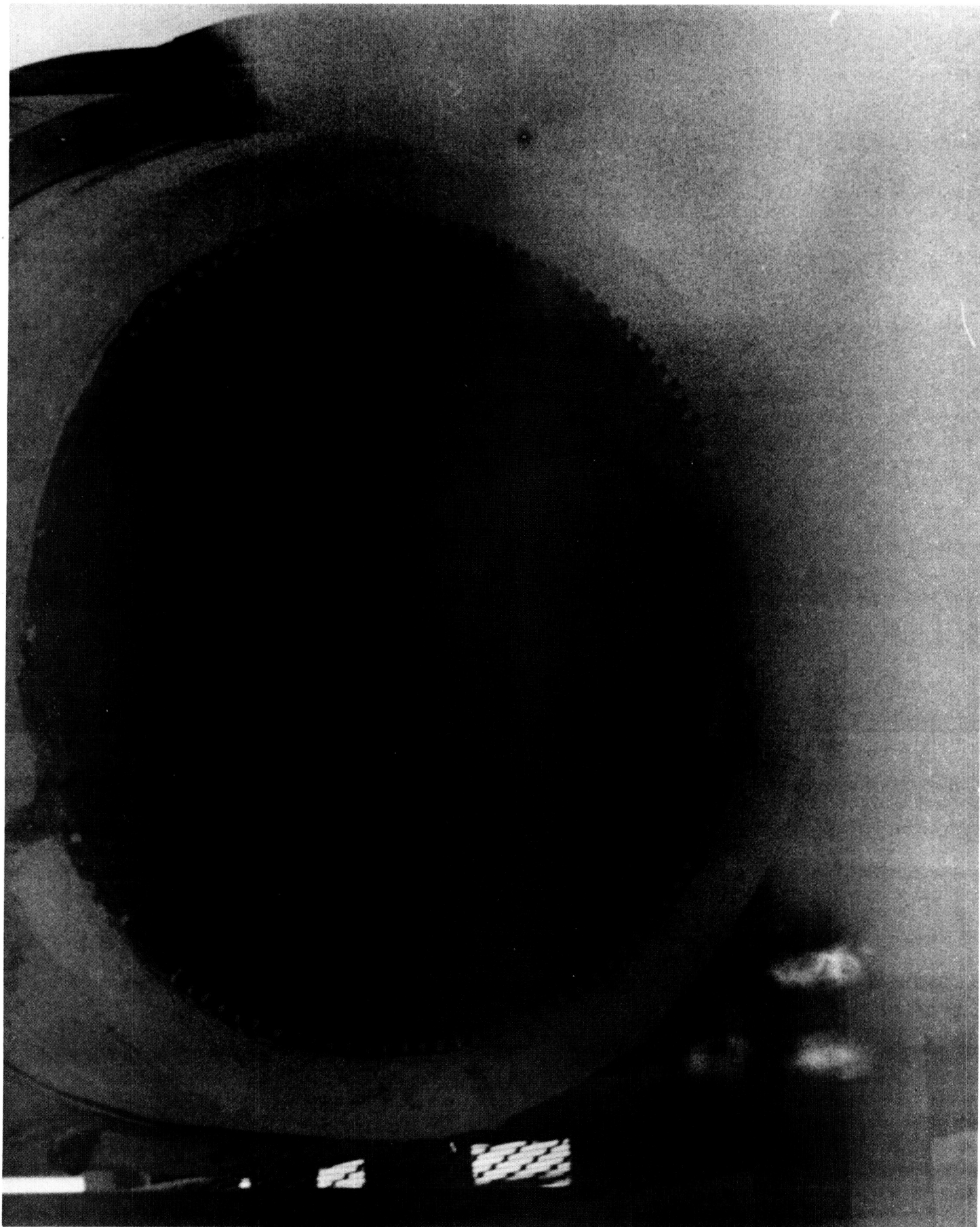
FROST HAS FORMED IN LH2 RECIRCULATION LINE BELLOWS AND BURST DISCS. FROST FINGERS ARE VISIBLE ON UMBILICAL PURGE VENTS



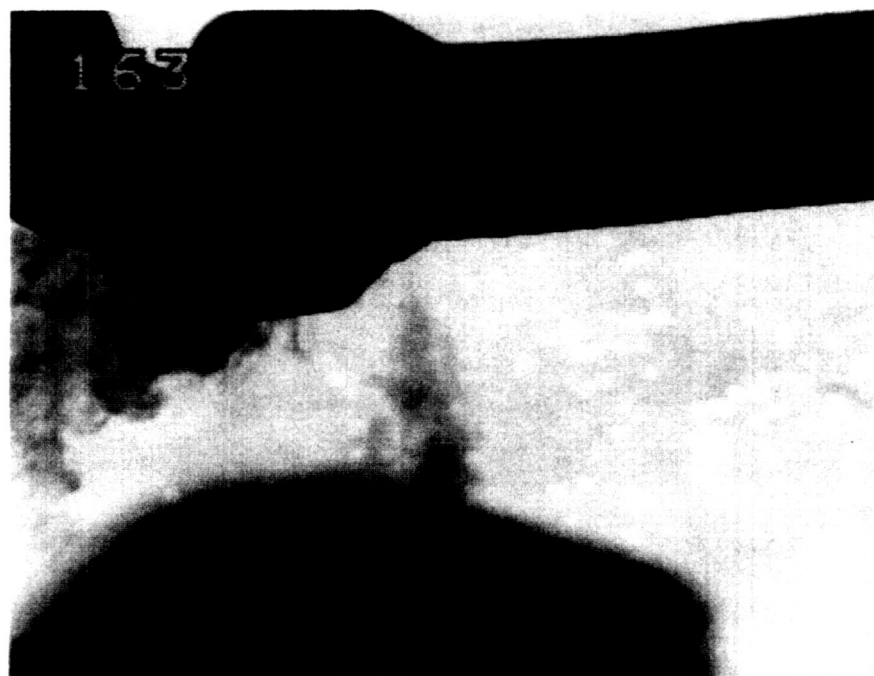
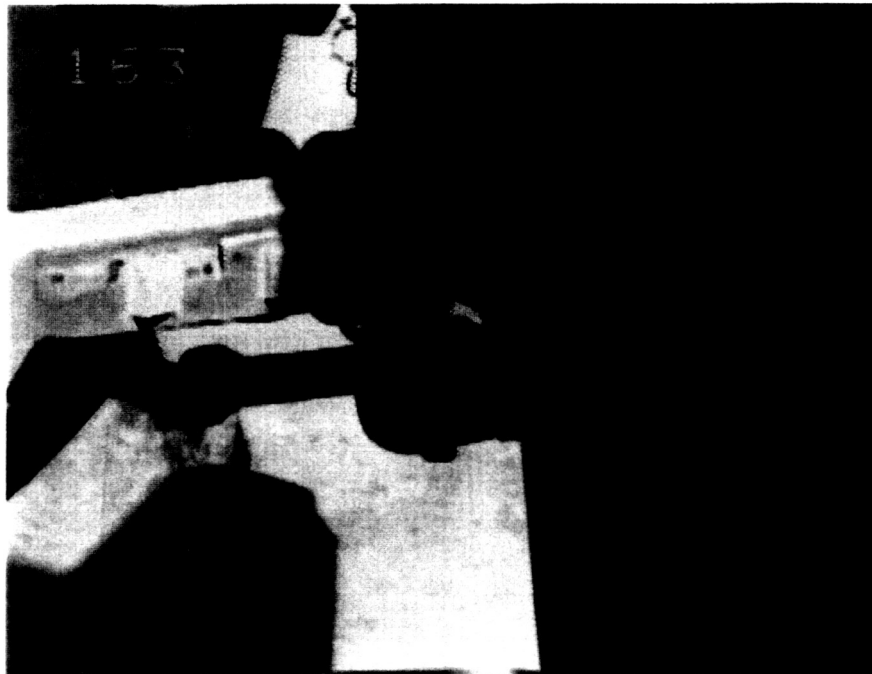
FROST HIGHLIGHTS THERMAL SHORT ALONG EDGE OF UMBILICAL
SEPARATION BOLT DEBRIS CANISTER



HYDROGEN LEAK DETECTOR TYGON TUBES ARE TEMPORARILY INSTALLED
WITH VELCRO STRAPS ON ET THRUST STRUT AND LH2 TANK PRESSLINE



RECENT MODIFICATIONS TO GOX VENT DUCT
PREVENTS FORMATION OF ICICLES AND FROST



CRYOPUMPING OCCURS ON LH2 RECIRCULATION LINE DURING TANK DRAIN

4.6 POST DRAIN INSPECTION

The STS-30R launch was scrubbed at T-31 seconds due to a malfunction in the SSME #1 recirculation pump. Both the LH2 and LO2 tanks had been filled to 100%. A post drain inspection of both the vehicle and MLP deck were performed at Pad 39B from 2120 to 2315 hours on 28 April 1989.

Examination of the ET LH2 recirculation line burst disc was inconclusive. The outside cover of the disc showed no visual damage with very little evidence of TPS erosion around the burst disc circumference.

No visible TPS damage, such as divots or cracks, was detected by the inspection team on the tank acreage or aft dome.

Some ice remained in the LH2 feedline bellows and LH2 recirculation line bellows. However, ice accumulation in these areas has occurred previously and is acceptable per NSTS-08303.

There appeared to be loose TPS between the LO2 feedline and the support brackets at stations XT-1377, 1623, and 1973. Some ice was visible in the bracket at station 1973. A "hands-on" inspection of the feedline was conducted and PR ET-29-TS-0135 documented loose foam on the LO2 feedline bellows area between the feedline and the intertank. Disposition called for the removal/trimming of the loose material.

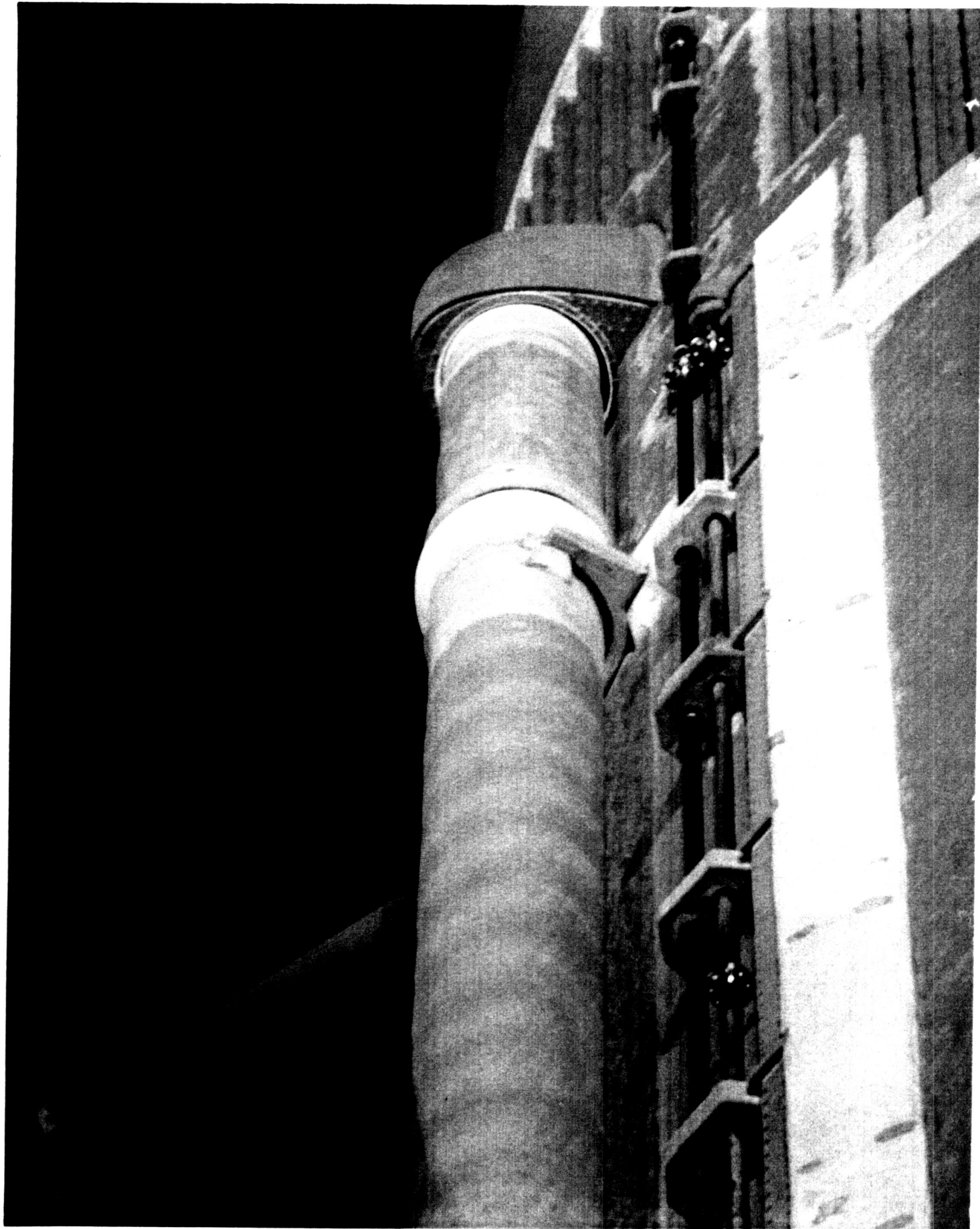
The tumble valve cover was in good condition. The nosecone -Y footprint area was missing topcoat and the grid mark. Inspection of the +Y side revealed one area of missing topcoat adjacent to the grid. Repairs were made per PR ET-29-TS-0134.

The paper cover on one of the left hand Orbiter aft +Z reaction control system thrusters was discolored. The probable cause for this condition was oxidizer vapor leaking through the thruster valve seat. The paper cover was replaced. Minor vapor leakage is expected and acceptable.

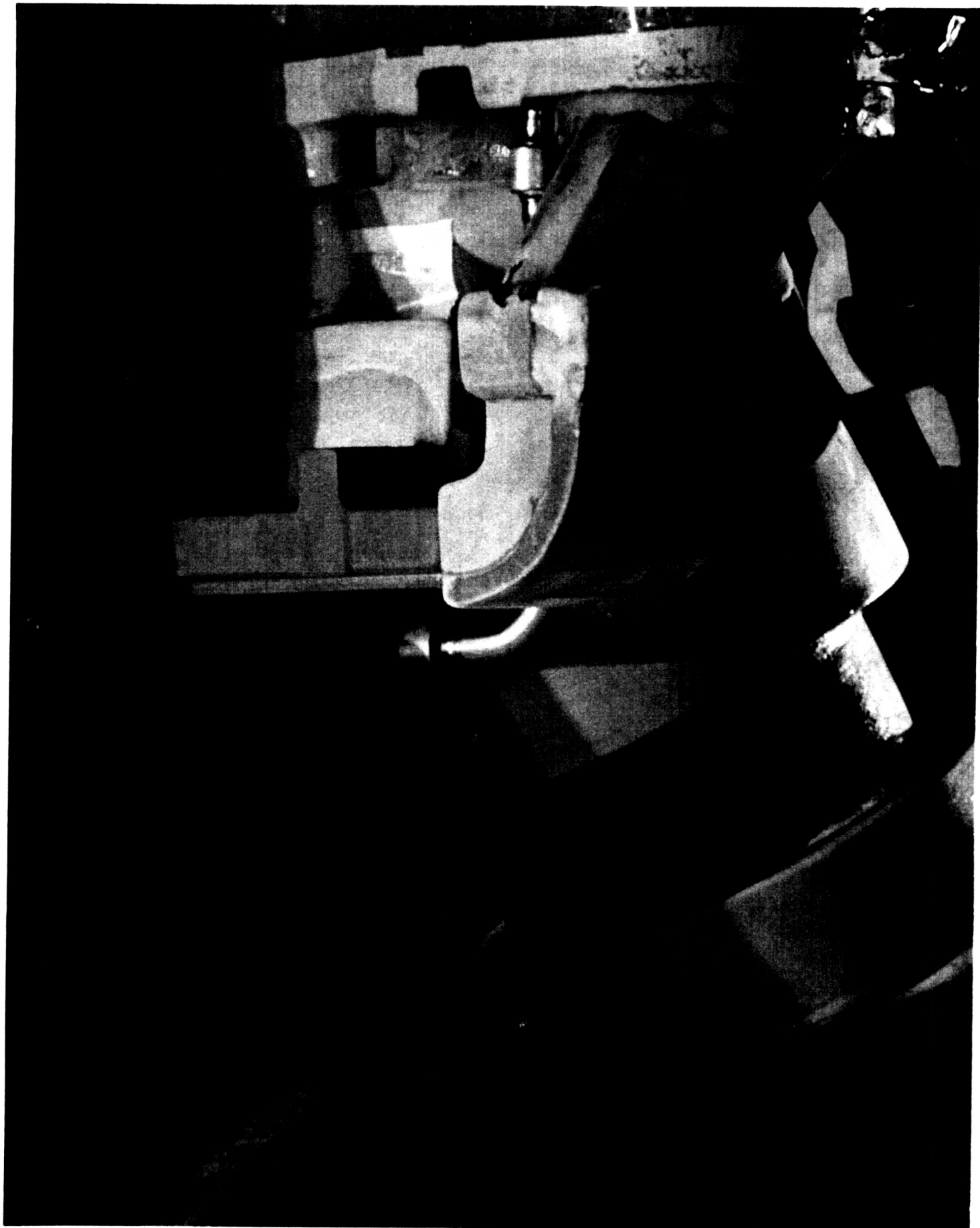
Pieces of a red quality tag were attached to the SSME #1 (12 o'clock position) and SSME #3 (6 o'clock position) vent tubing. These were removed prior to launch.

No SRB anomalies were visible to the inspection team.

Both the SSME #1 recirculation pump and the ET LH2 recirculation line were removed and replaced.



ICE REMAINS IN LO2 FEEDLINE BELLOWS XT 1106 AFTER DRAIN



HARD ICE FORMATION ON PURGE VENTS AFTER DRAIN

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HARD ICE IS PRESENT IN LH2 RECIRCULATION
LINE BELLOWS AND BURST DISC AFTER DRAIN



PIECES OF A RED QUALITY TAG ATTACHED TO
THE SSME #1 OXYGEN OVERBOARD VENT

5.0 PRE-TEST BRIEFING

The Ice/Frost/Debris Team briefing for launch activities was conducted on 4 May 1989 at 0900 hours with the following key personnel present:

C. Stevenson	NASA - KSC	Chief, ET Mechanical Systems Lead, Ice/Debris Assess Team
G. Katnik	NASA - KSC	ET Mech/TPS, Ice/Debris Assessment, STI
S. Higginbotham	NASA - KSC	STI, Debris Assessment
B. Speece	NASA - KSC	ET Processing, Ice Assess
B. Bowen	NASA - KSC	ET Processing, "SURFICE"
P. Feamster	NASA - KSC	ET Processing, Debris Assess
J. Rivera	NASA - KSC	ET Processing, Debris Assess
A. Oliu	NASA - KSC	"SURFICE", Debris Assess
M. Bassignani	NASA - KSC	ET Processing, Ice Assess
M. Young	LSOC - SPC	ET Processing, Ice Assess
J. Cawby	LSOC - SPC	ET Processing, Ice Assess
R. Seale	LSOC - SPC	ET Processing, Ice Assess
F. Huneidi	NASA - MSFC	TPS & Ice Assessment
D. Andrews	NASA - MSFC	Debris Assessment
D. Huntsman	NASA - JSC	Level II Debris Rep
Z. Byrns	NASA - JSC	Level II Integration
C. Gray	MMC - MAF	ET TPS & Materials Design
S. Copsey	MMC - MAF	ET TPS Testing/Certif
B. Fleming	MMC - KSC	ET Processing, LSS
J. McClymonds	RI - Downey	Debris Assess, LVL II Integ
A. Fazio	RI - KSC	Debris Assessment, LSS
H. Novak	USBI - PSE	SRB Processing
H. Huppi	MTI - Utah	SRM Plant Representative
G. Meeks	NASA - SSC	STI Operations
C. Thurman	NASA - SSC	STI Operations

5.1 PRE-LAUNCH SSV/PAD DEBRIS INSPECTION

The pre-launch debris inspection of the pad and Shuttle vehicle was conducted on 3 May 1989 from 1000 - 1300 hours. The detailed walkdown of Launch Pad 39B and MLP-1 also included the primary flight elements OV-104 Atlantis (4th flight), ET-29 (LWT-22), and BIO-27. Documentary photographs were taken of facility anomalies, potential sources of vehicle damaging debris, and new vehicle configurations.

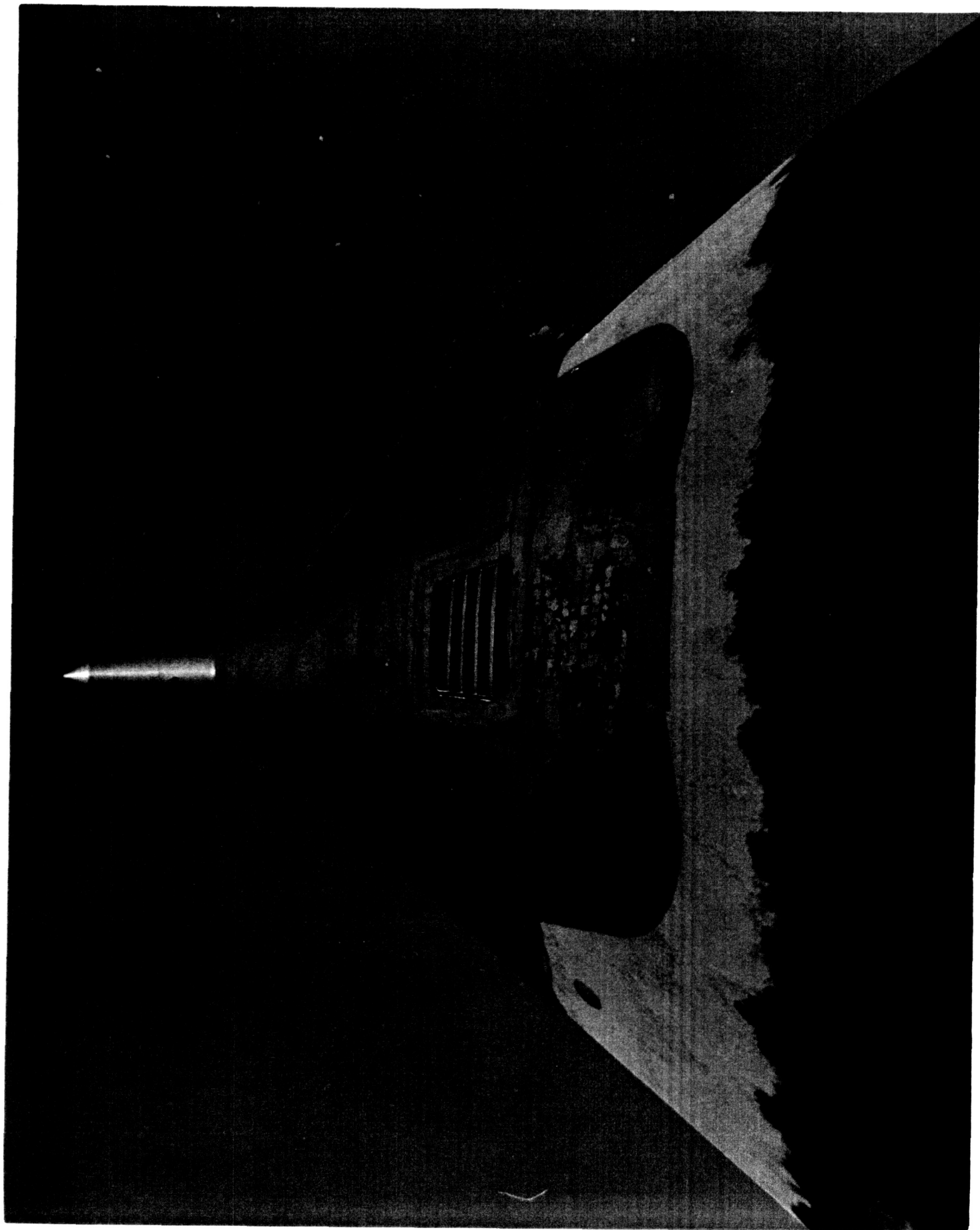
There were no major vehicle anomalies. The only minor anomaly was documented on a DR/IPR and consisted of two small pieces of red material near the SSME #1 nozzle GOX vent.

Cleanliness of the MLP deck had been generally maintained since the launch scrub. A holddown post optical target had come loose and lay in the bottom of a LH SRB secondary sound suppression water trough. BX-250 foam trimmings floated in the secondary sound suppression water troughs of both SRB exhaust holes. In addition, a piece of white RTV on holddown post #1 was loose. All three of these items were acceptable for launch.

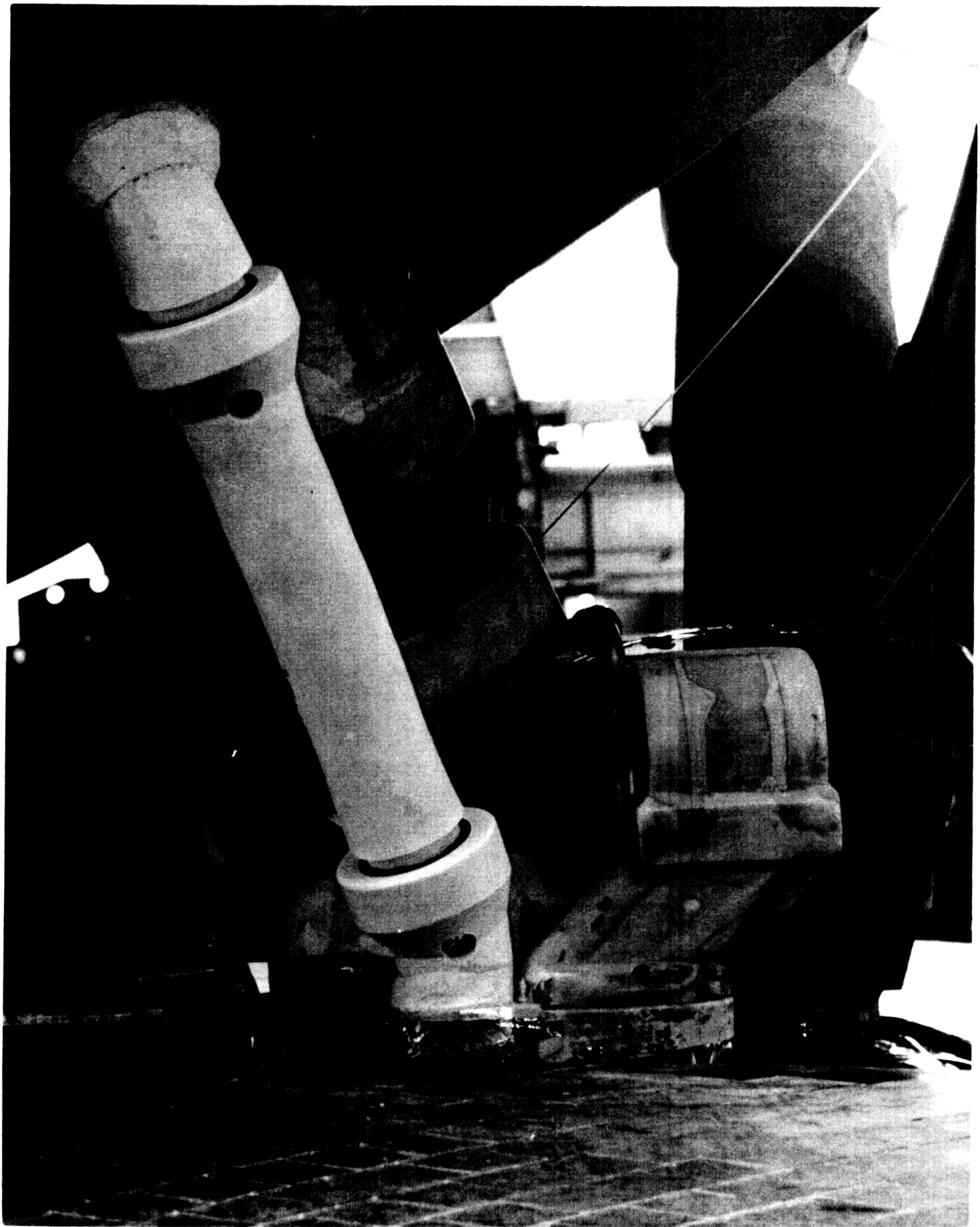
One bolt on the ramp to the MLP raised deck area was untertorqued. Vacuum putty in the bolt holes on the raised platform near the SSME flame hole (10 each locations on both right and left sides) required removal prior to launch. The facility discrepancies listed above were transferred to the pad leader and resolved prior to vehicle tanking.



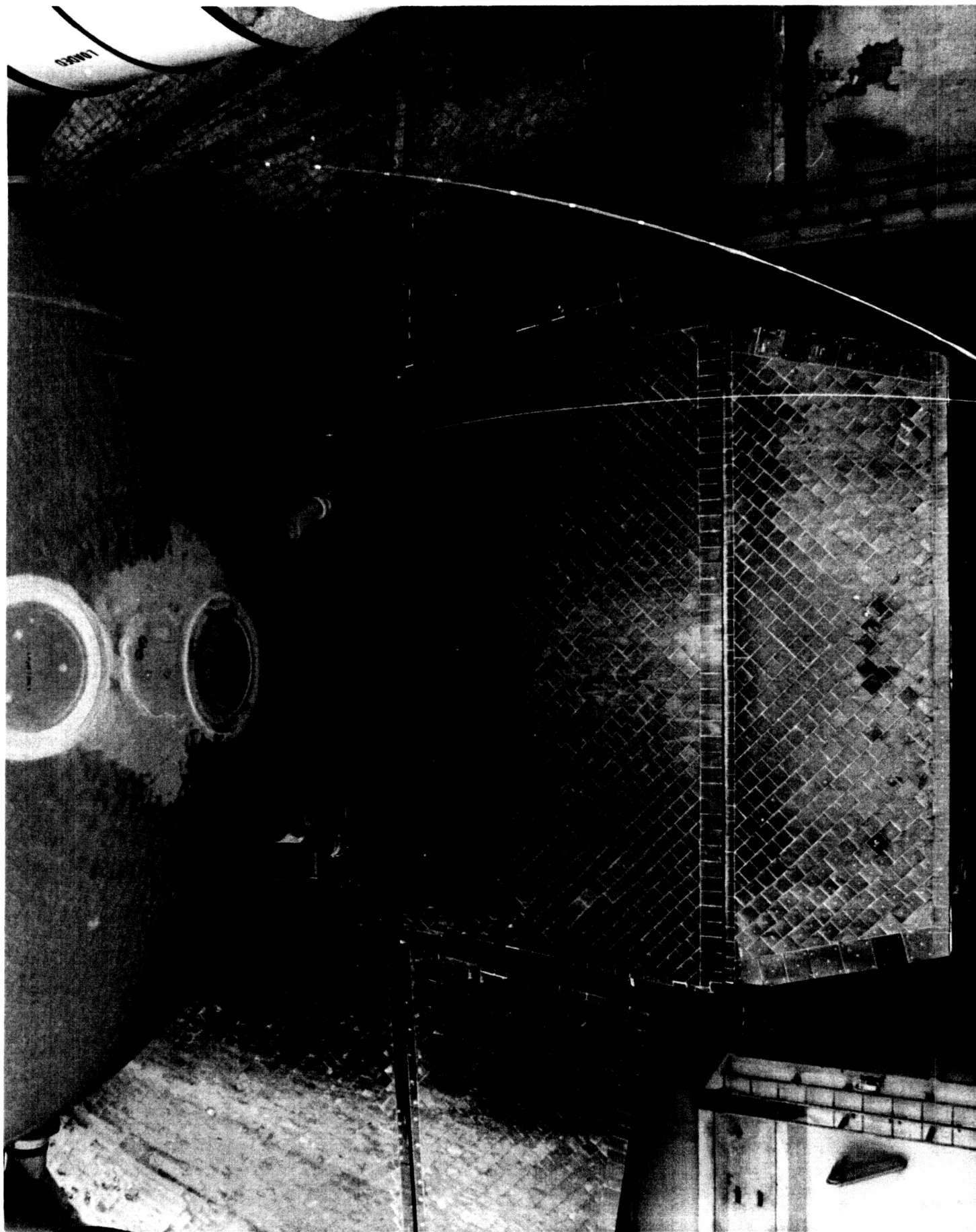
TWO PIECES OF RED QUALITY TAG ATTACHED
TO THE SSME #1 OXYGEN OVERBOARD VENT



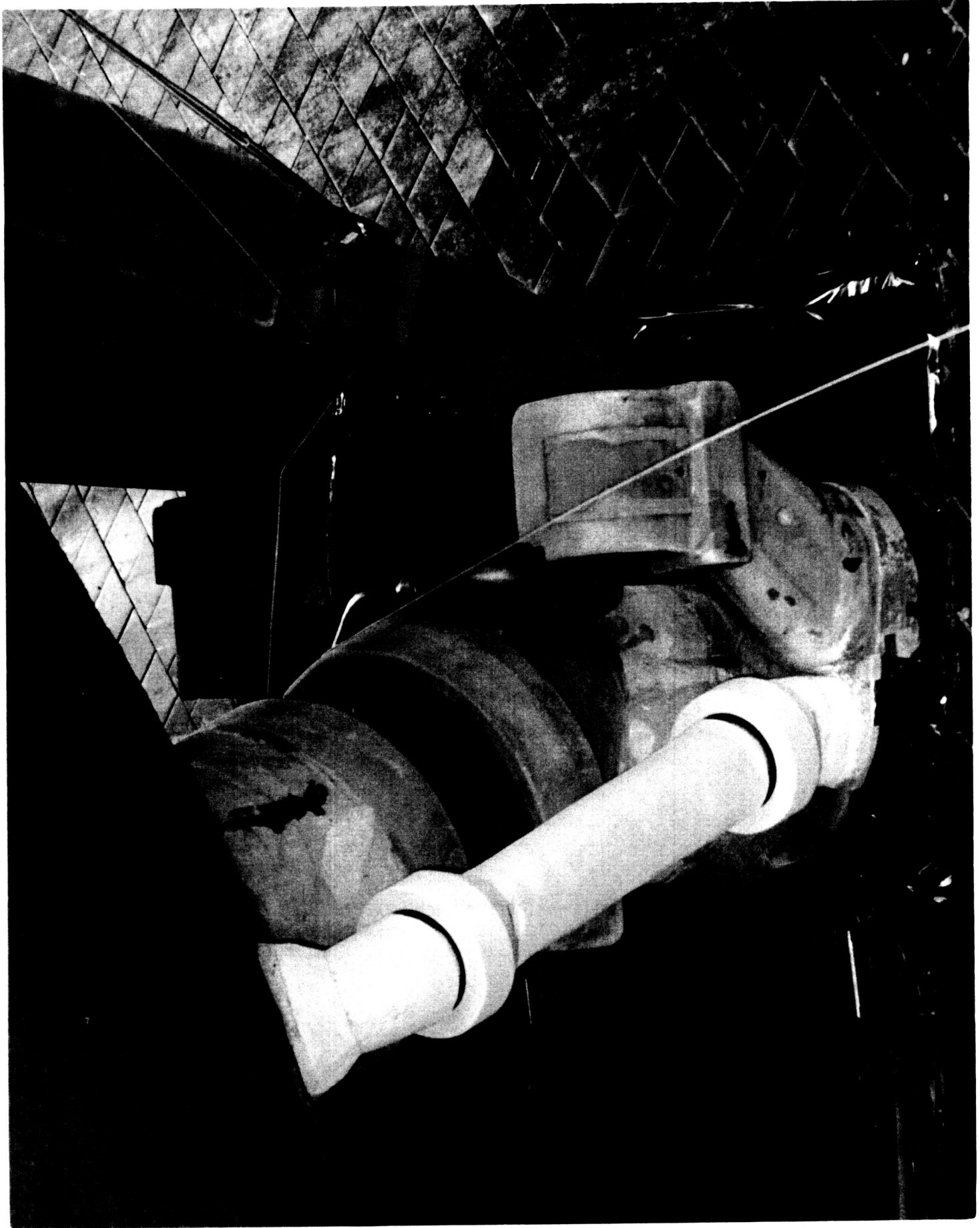
TOPCOAT REPAIR TO ET NOSECONE GOX DUCT FOOTPRINT/GRID



NEW LH2 RECIRCULATION LINE REPLACED AFTER SCRUB TURNAROUND



HYDROGEN LEAK DETECTOR REINSTALLED FOR SECOND LAUNCH ATTEMPT



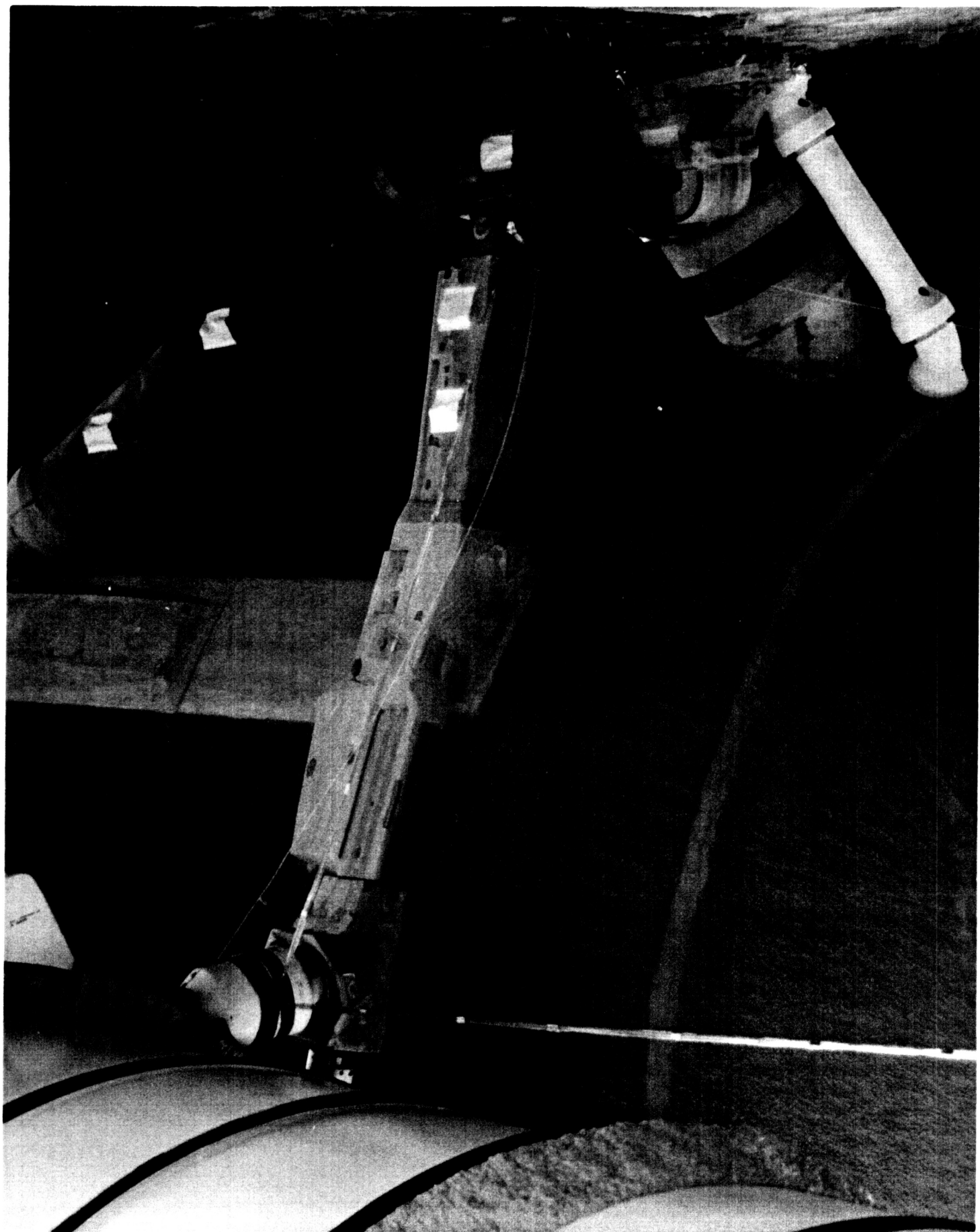
HYDROGEN LEAK DETECTOR POSITIONED ABOVE LH2 FEEDLINE AREA



TYGON TUBE IS ATTACHED TO ET THRUST STRUT WITH VELCRO STRAP

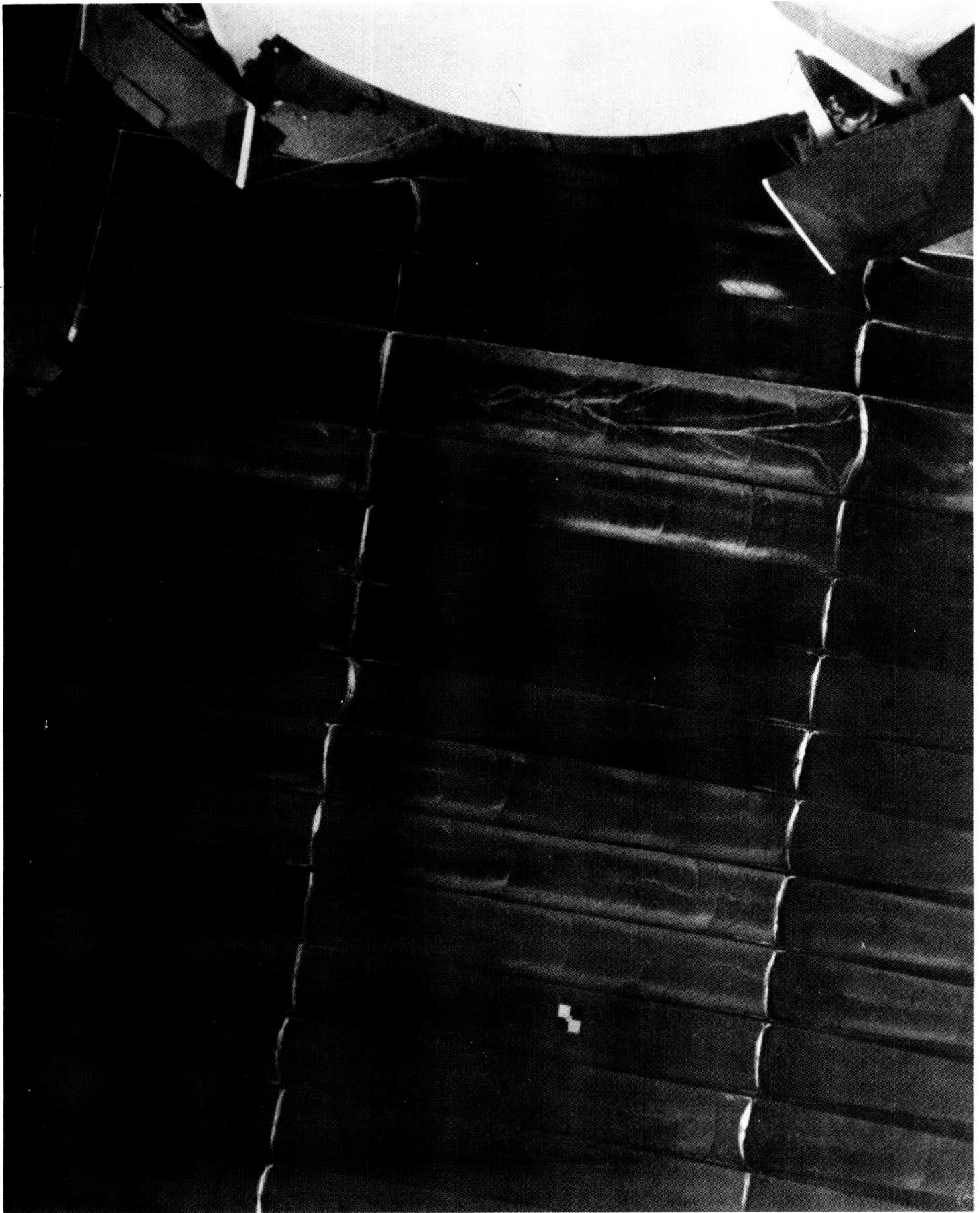
ORIGINAL PAGE

BLACK AND WHITE PHOTOGRAPH

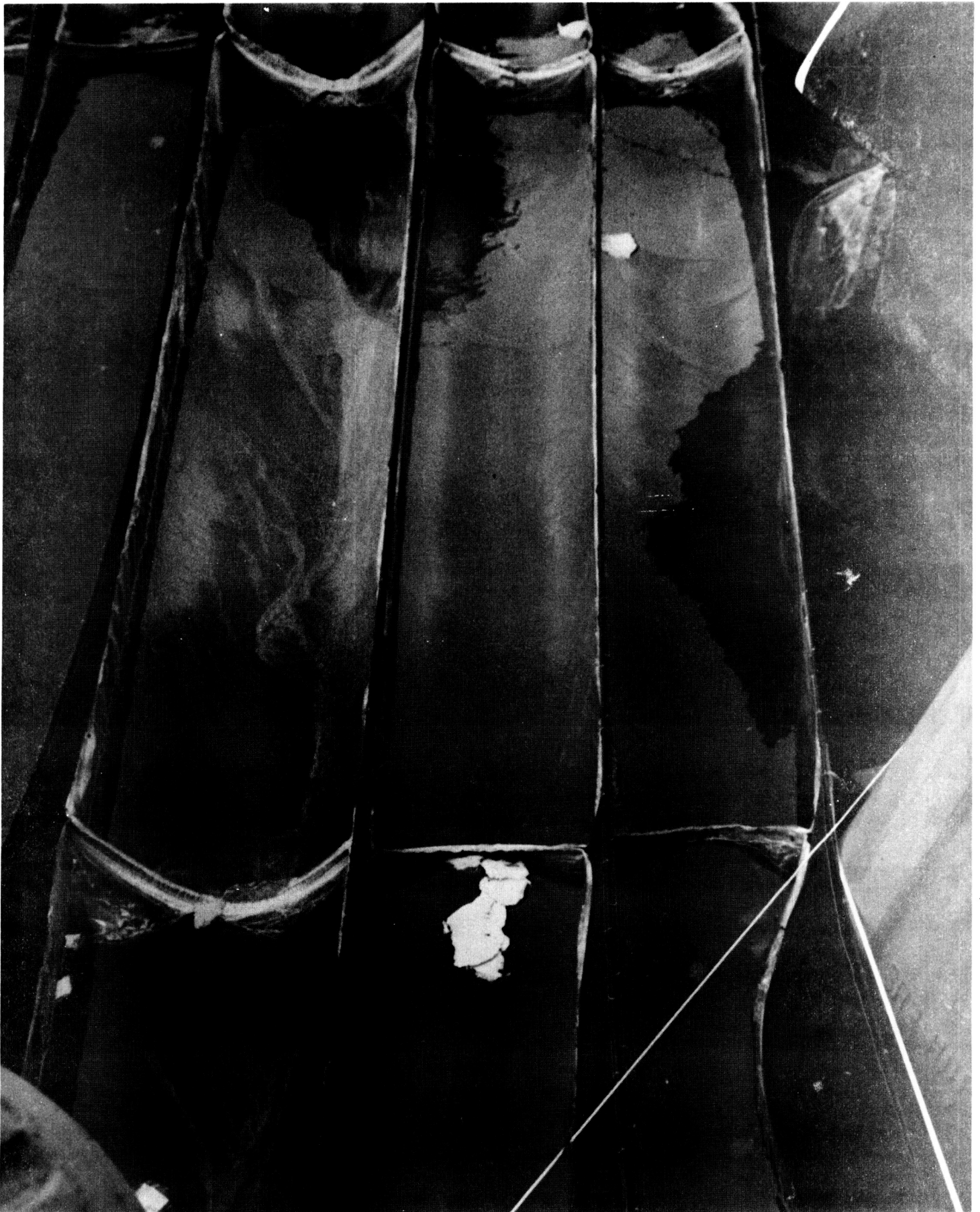


HYDROGEN LEAK DETECTOR TYGON TUBE IS ROUTED FROM UMBILICAL
ALONG ET/SRB CABLE TRAY TO STRUT AND DOWN TO MLP DECK

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH



LOOSE OPTICAL TARGET SUBMERGED IN SOUND
SUPPRESSION WATER TROUGH



BX-250 FOAM TRIMMINGS FLOAT IN THE SECONDARY SOUND
SUPPRESSION WATER TROUGHS OF BOTH SRB EXHAUST HOLES

6.0 LAUNCH

STS-30R was successfully launched at 2:47 pm EST on 4 May 1989.

6.1 ICE/FROST INSPECTION

The Ice/Frost Inspection of the cryo-loaded vehicle was performed on 4 May 1989 from 0820 to 1030 hours during the two hour built-in-hold at T-3 hours in the countdown. There were no violations of NSTS-08303 or Launch Commit Criteria except for IPR 30RV-0290 (inverted "Y" crack on ET/ORB LH2 umbilical). Ambient weather conditions at the time of the inspection were:

Temperature:	74.7 F
Relative Humidity:	62.6 %
Wind Speed:	9 Knots
Wind Direction:	100 Degrees

The portable STI infrared scanner was utilized to obtain surface temperature measurements for an overall thermal assessment of the vehicle, as shown in Figures 6 and 7.

6.2 ORBITER OBSERVATIONS

No Orbiter tile anomalies were observed. The average Orbiter surface temperature ranged from 76 to 80 degrees F. An RCS paper cover on the forward RCS -Y side was wet and appeared to have a very small amount of water 1/4-inch deep inside. The surface temperatures of the SSME engine mounted heat shields were recorded as 72 degrees F for SSME #1 (32 degrees F at the interface), 66 degrees F for SSME #2 (32 degrees F at the interface), and 75 degrees F for SSME #3 (65 degrees F at the interface). Some frost was present at the engine to heat shield interface of SSME #1 and SSME #2 while SSME #3 had none. No condensate was present on the aft heat shield or drain holes.

6.3 SRB OBSERVATIONS

The STI portable infrared scanner recorded both RH and LH SRB case surface temperatures between 74 to 78 degrees F. The IR scanner showed no cooling effects on the SRB's from the External Tank. Temperatures for the SRB field joints/heaters ranged from 81 to 86 degrees F. The predicted Propellant Mean Bulk Temperature (PMBT) supplied by MTI was 71 degrees F.

All thermal curtain tape was in place. All closeouts were intact. The LH SRB fwd field joint secondary heater circuit had failed prior to the countdown, but the primary heater supported the launch. No SRB anomalies were observed.

TIME: 0900-1030
DATE: 5/4/89
VEH. STS- 30R

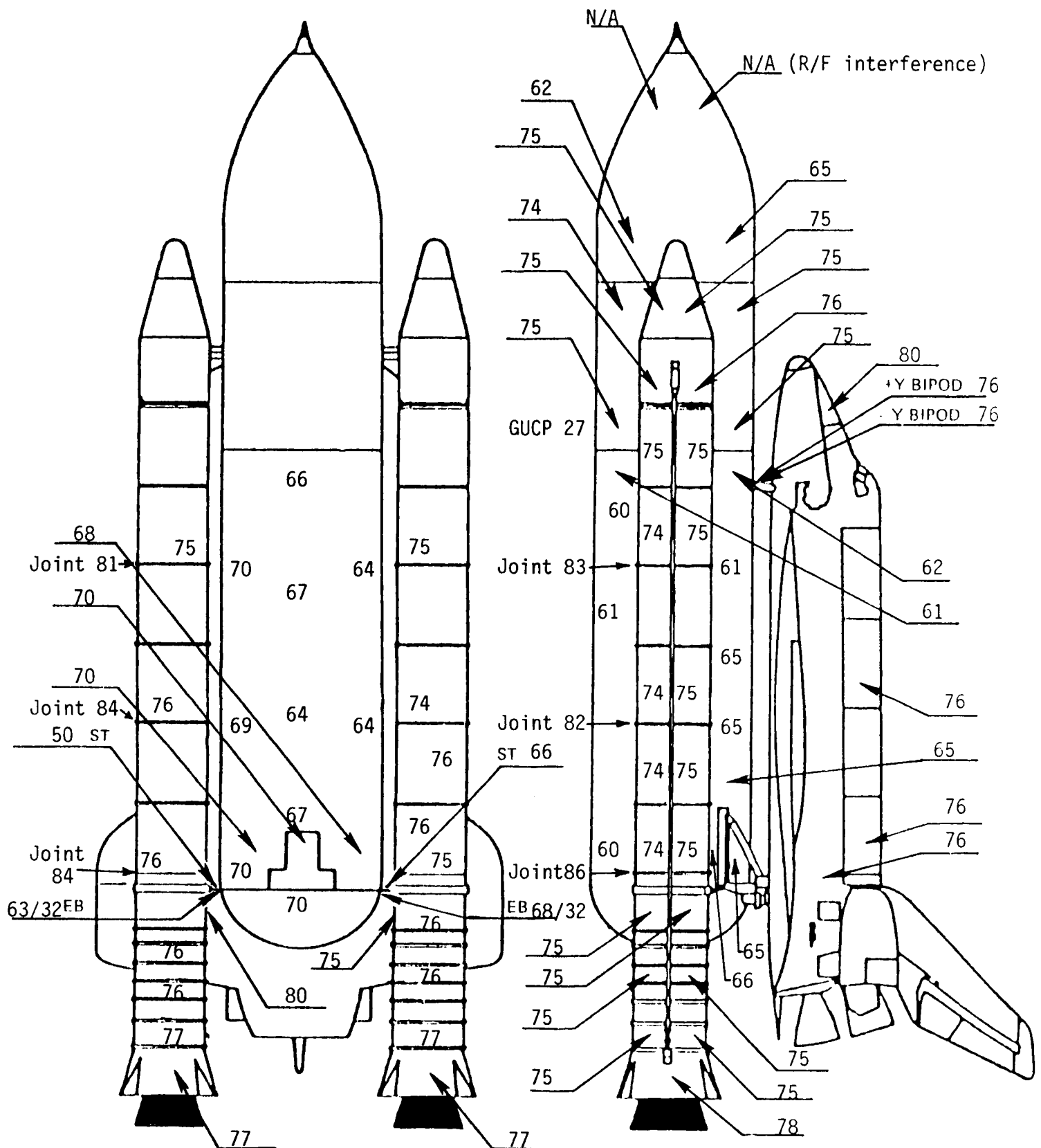
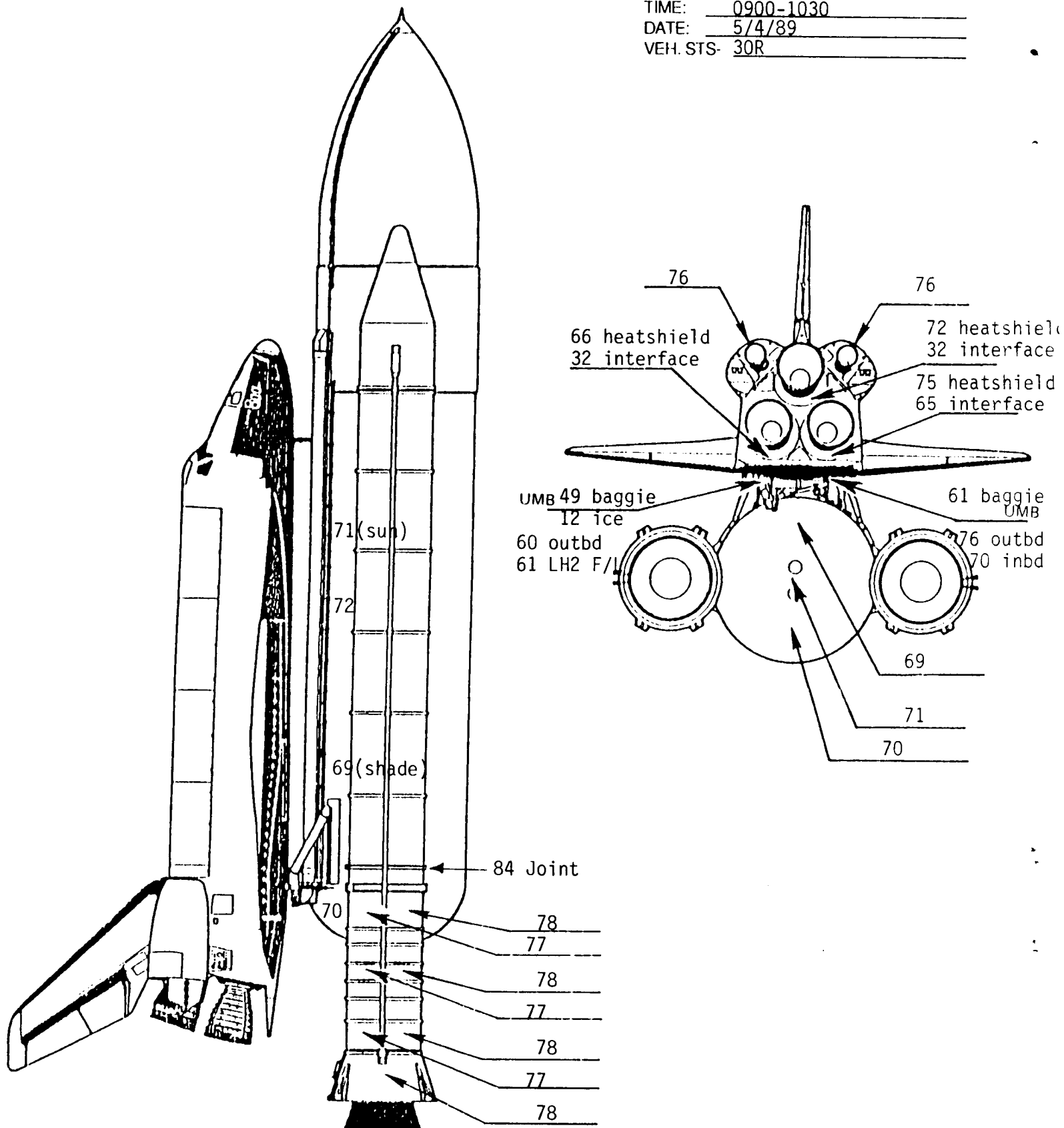


FIGURE 7. INFRA-RED SCANNER SSV SUMMARY DATA

TIME: 0900-1030

DATE: 5/4/89

VEH. STS- 30R



6.4 EXTERNAL TANK OBSERVATIONS

The ice/frost SURFICE computer program was run from 0530 to 1445 hours and the results tabulated in Figures 8, 9, and 10. The program predicted condensate with no ice accumulation on all ET TPS acreage.

Condensate, but no ice or frost, was present on the LO2 tank. The tank was wet from rain with some run-off. The tumble valve cover was intact with no protrusion. No leakage had occurred around the GOX seals. The average skin temperature of the LO2 tank barrel was 62-65 degrees F (temperature measurements could not be taken on the LO2 tank upper ogive due to payload R/F interference with the scanner equipment).

Thirteen small ice areas had formed at the intertank to LO2 tank interface flange on the stringer closeout. Since this formation occurred in the -Y-Z quadrant and was out of the debris zone, this condition was acceptable per NSTS-08303. The average surface temperature of the intertank was 75 degrees F.

The average surface temperature of the LH2 tank was 60 to 72 degrees F and there was no ice or frost on the acreage areas. Ice/frost had formed under two barrymounts at stations XT-1722 and 1787, which was acceptable per NSTS-08303. Ice was present in the LO2 feedline bellows. LO2 feedline attachments exhibited nominal amounts of ice/frost and these accumulations were permissible per NSTS-08303. Both +Y and -Y longeron crotch areas had cracks in the SOFI with no ice, frost, or indication of extreme cold as measured by the IR scanner. These are acceptable per NSTS-08303.

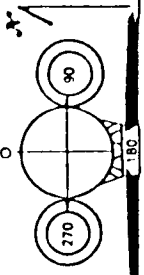
Ice had formed on the ET/ORB LO2 umbilical purge vents and on both inboard and outboard sides of the baggie. This condition has been observed before and is acceptable per NSTS-08303. Surface temperature measurements on the acreage areas of the umbilical averaged 70 degrees F.

Typical amounts of frost were visible in the LH2 umbilical feedline bellows. Frost fingers had formed on the purge vents. Heavy, slightly more than normal, ice was present on the top and outboard side of the LH2 umbilical. Ice had formed on the SOFI closeout at the feedline to tank interface. The formation was approximately 5 inches long and acceptable per NSTS-08303. There was no evidence of a LH2 leak, condensate run-off, or any liquid air generation. In general, the umbilical measured 12 degrees F on the ice areas and approximately 65 degrees on the acreage areas.

A 6-inch long crack in the shape of an inverted "Y" was visible on the LH2 umbilical -Z surface in the MBO-130-149 foam between the 17-inch feedline and recirculation line. The crack was outlined by frost only and did not appear to have loose or debonded SOFI. This phenomenon had not been observed before and

STS- 30R		TEST:		Launch			DATE: 5/4/89		T-0 TIME: 1447		DATE: 5/4/89		0		
ORBITER	ET	SRB	MLP	PAD	LO2	LM2		CHILLDOWN TIME: 0516		FAST FILL TIME: 0547		CHILLDOWN TIME: 0516		FAST FILL TIME: 0547	
OV- 104	29	B1027	1	39B	LO2 TANK STA 370 TO 540		LO2 TANK STA 550 TO 852		LO2 TANK STA 1130 TO 1380		LO2 TANK STA 1380 TO 2058		LO2 TANK STA 1380 TO 2058		
LOCAL TIME		CONDITIONS		WIND		WIND		WIND		WIND		WIND		WIND	
TEMP. OF	REL. HUM. %	DEW PT OF	WIND VEL KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP OF	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP OF	COND RATE IN/HR	ICE RATE IN/HR	REGION
0915	74.0	68	63.13	10	88	II	5.90	61.48	0.0009	0.1931	II	5.90	57.75	0.0028	0.1627
0930	74.1	67	62.82	9	90	II	5.31	60.91	0.0010	0.1750	II	4.95	55.51	0.0031	0.1297
0945	74.5	66	62.79	10	89	II	5.90	61.48	0.0007	0.1929	II	5.90	56.52	0.0030	0.1462
1000	74.5	66	62.79	11	98	II	6.49	61.83	0.0006	0.2096	II	6.05	57.22	0.0029	0.1615
1015	74.4	65	62.26	8	110	II	4.72	60.23	0.0009	0.1568	II	4.40	54.34	0.0029	0.1130
1030	74.3	65	62.17	11	109	II	5.49	61.37	0.0005	0.2055	II	6.49	57.90	0.0024	0.1751
1045	75.4	64	62.81	13	101	I	7.67	62.76	0.0000	0.2463	II	7.15	58.78	0.0025	0.1954
1100	75.6	63	62.57	13	106	I	7.67	62.83	0.0000	0.2455	II	7.15	58.70	0.0024	0.1947
1115	76.0	61	62.06	12	114	I	7.08	62.54	0.0000	0.2274	II	3.84	53.82	0.0027	0.1010
1130	75.6	61	61.67	11	108	I	6.49	61.61	0.0000	0.2074	II	6.05	57.02	0.0024	0.1598
1145	76.8	61	62.84	12	110	I	7.08	63.38	0.0000	0.2350	II	6.60	58.88	0.0023	0.1852
1200	77.3	59	62.39	14	109	I	8.26	64.97	0.0000	0.2678	II	7.70	59.77	0.0018	0.2155
1215	77.1	58	61.72	13	118	I	7.67	64.20	0.0000	0.2461	II	4.16	54.88	0.0024	0.1120
1230	78.2	57	62.31	11	121	I	6.49	63.99	0.0000	0.2201	II	3.52	54.33	0.0025	0.0984
1245	77.4	47	61.53	11	119	I	6.49	63.18	0.0000	0.2131	II	3.52	53.45	0.0024	0.0939
			</												

Figure 9. Ice/Frost Computer Predictions

STS - 30R			TEST: Launch			DATE: 5-4-89		T-0 TIME: 1447		DATE: 5/4/89																
ORBITER	ET	SRB	MLP	PAD	LO2	CHILLDOWN TIME: 0525		FAST FILL TIME: 0600		CHILLDOWN TIME: 0516		FAST FILL TIME: 0547														
OV- 104	29	B1027	1	39B		SLOW FILL TIME: 0548		REPLENISH TIME: 0803		SLOW FILL TIME: 0519		REPLENISH TIME: 0756														
LOCAL TIME	CONDITIONS										LM2 TANK STA 370 TO 540				LM2 TANK STA 550 TO 852				LM2 TANK STA 1130 TO 1380				LM2 TANK STA 1380 TO 2058			
	TEMP. OF	REL. HUM. %	DW PT OF	WIND VEL KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP OF	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP OF	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP OF	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP OF	COND RATE IN/HR	ICE RATE IN/HR	
1300	76.4	57	60.56	13	121	I	7.67	63.45	0.000	0.2363	II	7.67	58.81	0.011	0.2056	II	4.16	53.84	0.023	0.1060	I	18.07	64.44	0.000	0.4693	
1315	76.4	57	60.56	10	118	I	5.90	61.41	0.000	0.1883	II	5.90	57.24	0.016	0.1584	II	3.20	51.45	0.024	0.0794	I	13.90	61.99	0.000	0.3626	
1330	77.8	56	61.43	11	118	I	7.67	64.82	0.000	0.2470	II	7.67	59.92	0.010	0.2160	II	4.16	55.06	0.023	0.1130	I	18.07	65.77	0.000	0.4899	
1345	76.0	57	60.17	11	111	I	6.49	61.77	0.000	0.2009	II	6.49	57.44	0.015	0.1709	II	6.05	56.31	0.019	0.1541	I	13.42	61.27	0.000	0.3443	
1400	76.8	57	60.95	12	110	I	7.08	63.25	0.000	0.2240	II	7.08	58.77	0.013	0.1935	II	6.60	57.72	0.018	0.1753	I	14.64	62.89	0.000	0.3879	
1415	78.2	56	61.81	11	103	I	6.49	63.96	0.000	0.2174	II	6.49	59.38	0.014	0.1869	II	6.05	58.28	0.018	0.1693	I	13.44	63.39	0.000	0.3724	
1430	77.2	56	60.85	11	115	I	6.49	62.95	0.000	0.2087	II	6.49	58.36	0.014	0.1784	II	3.52	52.94	0.023	0.0913	I	15.29	63.67	0.000	0.4063	
1445	77.6	55	60.73	12	109	I	7.08	63.99	0.000	0.2258	II	7.08	58.97	0.011	0.1953	II	6.60	57.95	0.015	0.1771	I	14.64	63.64	0.000	0.3908	
T-0	77.8	56	61.43	13	113	I	7.67	64.84	0.000	0.2470	II	7.67	59.92	0.010	0.2160	II	4.16	55.06	0.023	0.1130	I	18.07	65.77	0.000	0.4900	
AVG.	74.7	65	62.63	9	E			60.47					55.45					53.12						59.04		

EGGV-340

Figure 10. Ice/Frost Computer Predictions

documented on IPR 30RV-0290. Cracks of this type are normally associated with thermal stress or movement (substrate deformation), which is not predicted in this area. The IPR was upgraded to PR ET-29-TS-0136 with disposition to use-as-is per MRB action.

The recently replaced LH2 recirculation line showed no evidence of SOFI cracking. Frost had formed only in the bellows. Some ice had accumulated on both burst disks.

There was no ice or frost on the ET/ORB LH2 cable tray. No vapors were emanating from the vent hole. The infrared scanner measured the cable tray surface temperature at 68 degrees F.

The ice/frost accumulation on the ET/SRB fittings from the tank interface outboard to the strut pin hole was typical. There was condensate on the rest of the EB fitting, but no ice/frost/condensate on the ET/SRB struts.

The summary of ice/frost team observation anomalies consists of 9 OTV and ice inspection observations:

Anomaly 001 documented vapors in the vicinity of the intertank and LO2 interface directly above the flight door. The vapors were continuous until ice/frost developed. The ice/frost subsequently washed away by rain water. This condition was not a debris concern.

Ice/frost formed on the -Y side of the ET/ORB LH2 umbilical (Anomaly 002). The condition was acceptable per NSTS-08303.

Approximately 13 iceballs formed at the LO2 tank to intertank splice in the -Y-Z quadrant (same general area as Anomaly 001) and were recorded as Anomaly 003. The ice/frost formation is associated with LO2 tank to intertank closeout and is acceptable per NSTS-08303.

Anomaly 004 discolored RCS paper cover on the -Y FWD RCS thruster. This condition was assessed by the Ice Team to be rain water 1/4-inch deep inside the thruster nozzle and is no debris concern.

A crack developed in the crotch area (Anomaly 005) of the +Y longeron to thrust strut interface approximately 12 inches long, but is acceptable per NSTS-08303.

A 6-8 inch crack in the crotch area of the -Y longeron to thrust strut interface was recorded on Anomaly 006 and is acceptable per NSTS-08303.

Anomaly 007 documented frost spots behind the barrymounts at stations XT-1722, 1787. The frost is located on the closeout line of the barrymounts and is acceptable per NSTS-08303.

A 5-inch long ice growth appeared on the LH2 feedline to aft dome interface (Anomaly 008) and is circumferential to the feedline. This growth is associated with the TPS closeout line and is acceptable per NSTS-08303.

Anomaly 009 recorded an approximately 6-inch long, inverted "Y" shaped crack on the ET/ORB LH2 umbilical -Z face. The crack is located in the MBO-130-149 foam between the LH2 feedline and recirculation line. IPR 30RV-0290 documented the condition, was upgraded to PR ET-29-TS-0136, and was assessed to be an acceptable condition per MRB action.

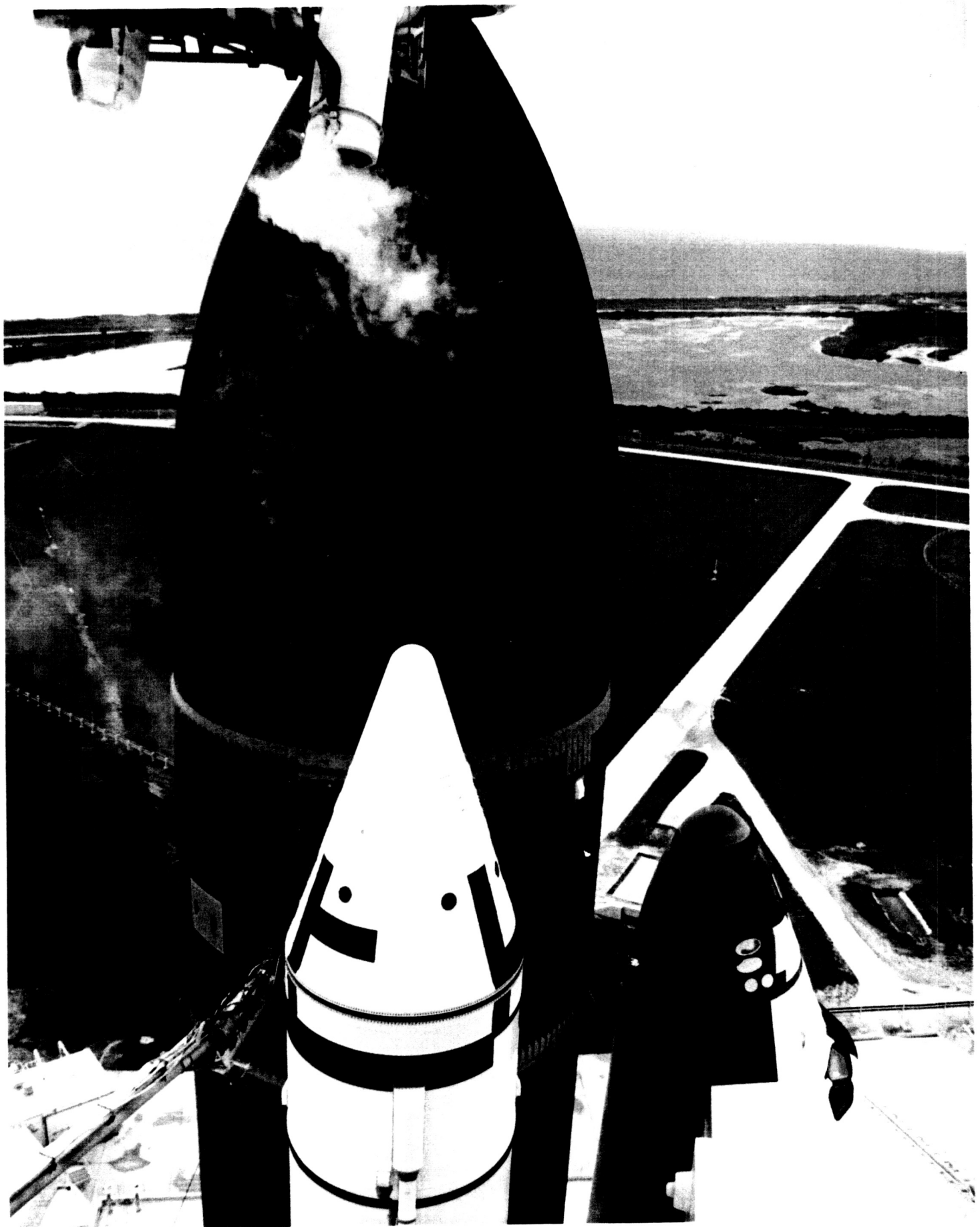
Observed ET Post Launch Anomalies are listed in Section 12.0.

6.5 FACILITY OBSERVATIONS

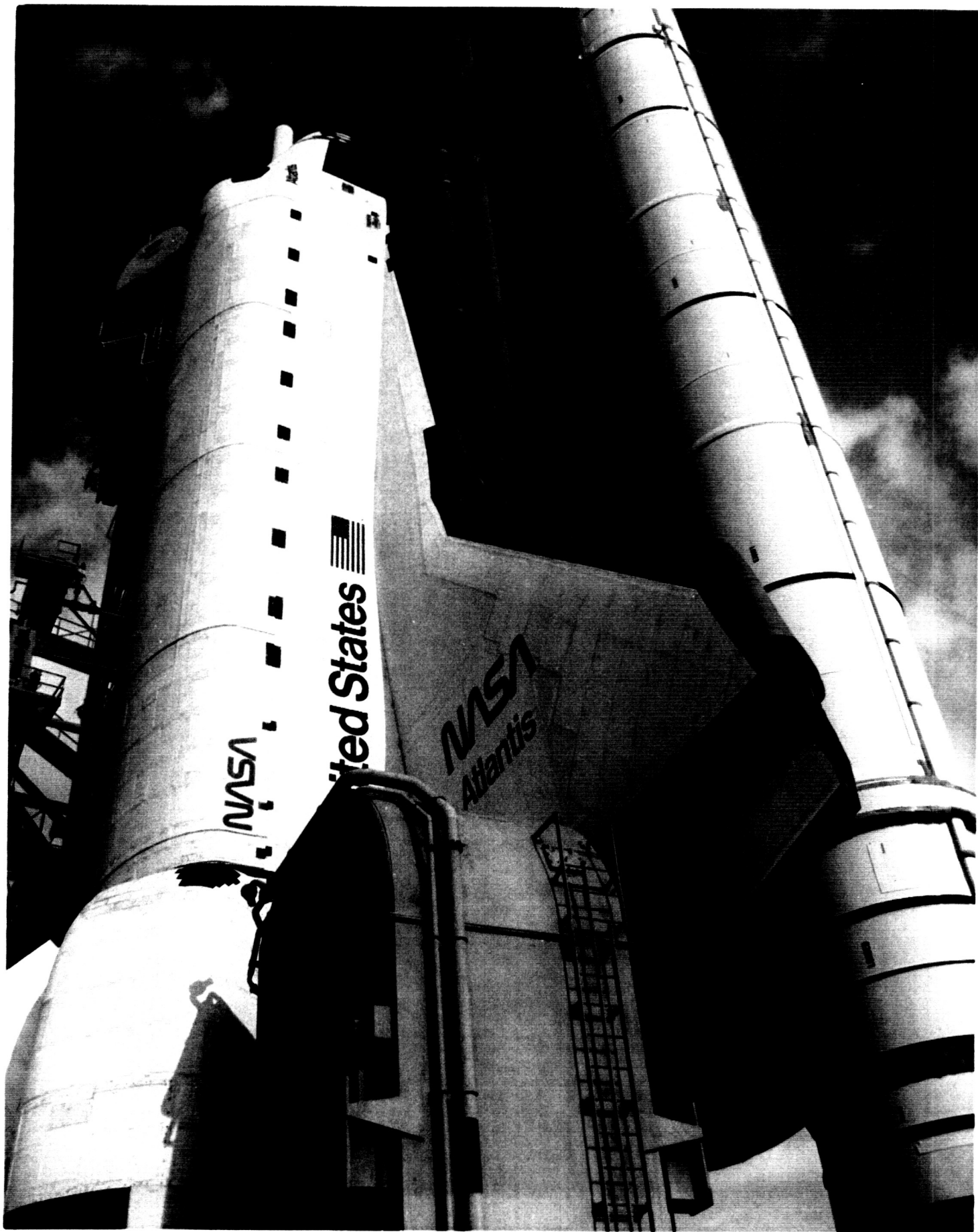
No anomalies were observed on the launch facility, access arms, or pad. Ice/frost had accumulated on the LH2 and LO2 T-0 umbilicals, but there were no leaks. The return-to-flight modifications to the GH2 vent arm prevented ice from forming. The GUCP had accumulated some frost on the tank side of the interface. The temperature sensor instrumentation cable on the GOX vent ducts was lightly coated with frost, but there was no ice or icicles on the ends of the vent ducts. The recent modification to drill more exhaust holes on the ends of the ducts was working satisfactorily and an even heating distribution was observed with the IR scanner. Visual and infrared observations of the GOX seals confirmed no leakage. No new pad debris concerns were noted.



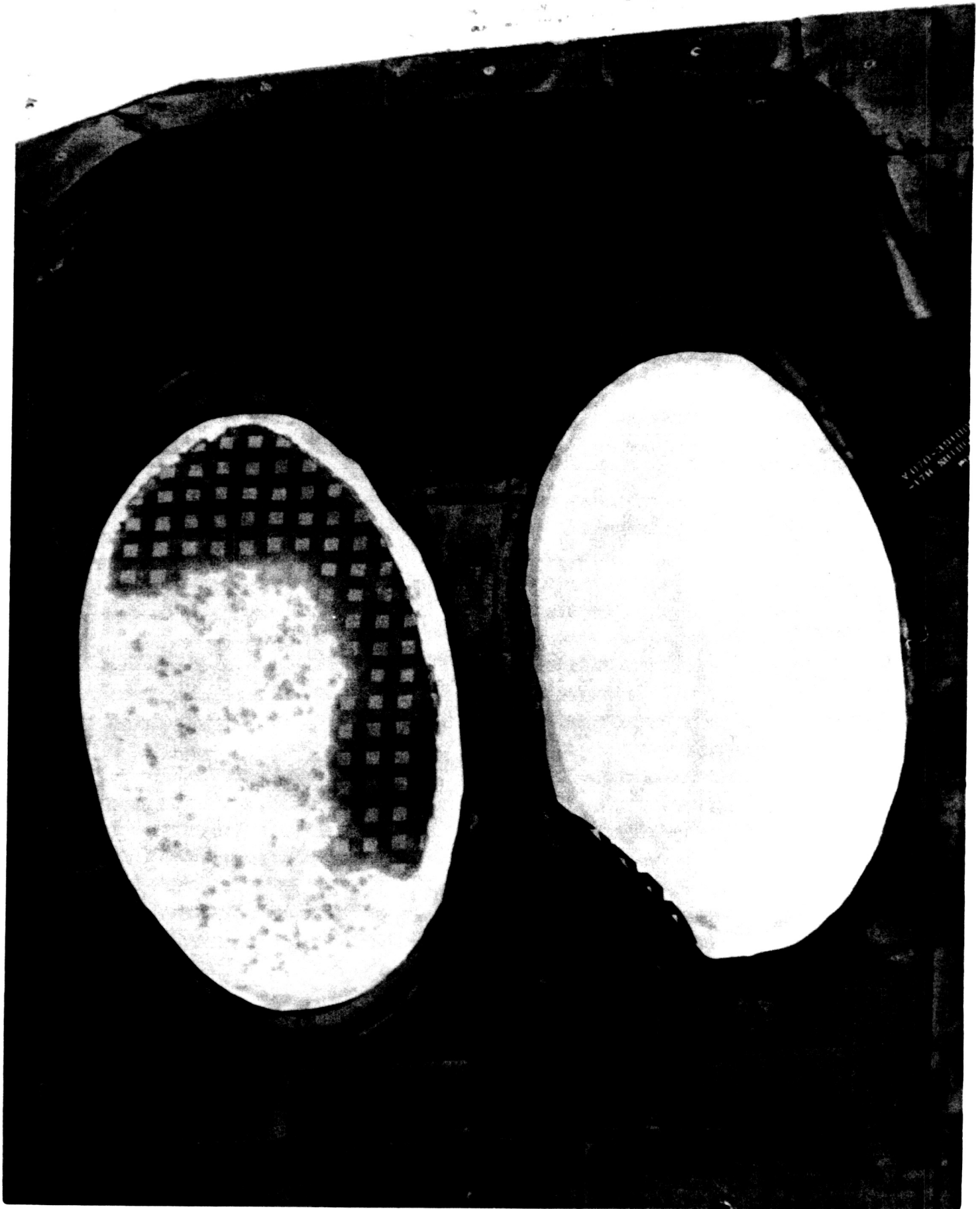
OVERALL VIEW OF EXTERNAL TANK -Z SIDE



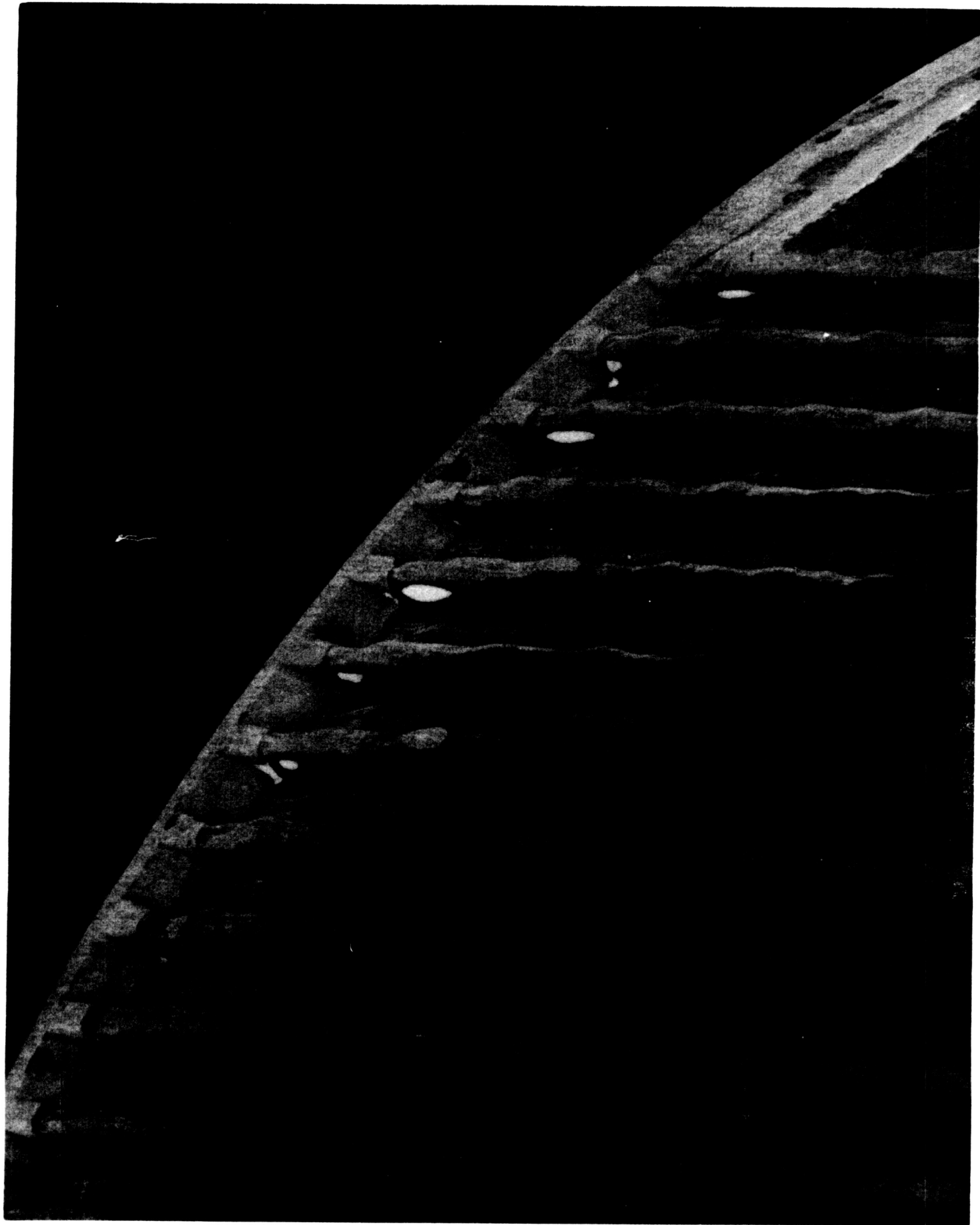
OVERALL VIEW OF EXTERNAL TANK -Y LO2 TANK. SLIGHTLY MORE
GASEOUS OXYGEN IS VENTING FROM NORTH GOX EXHAUST DUCT.



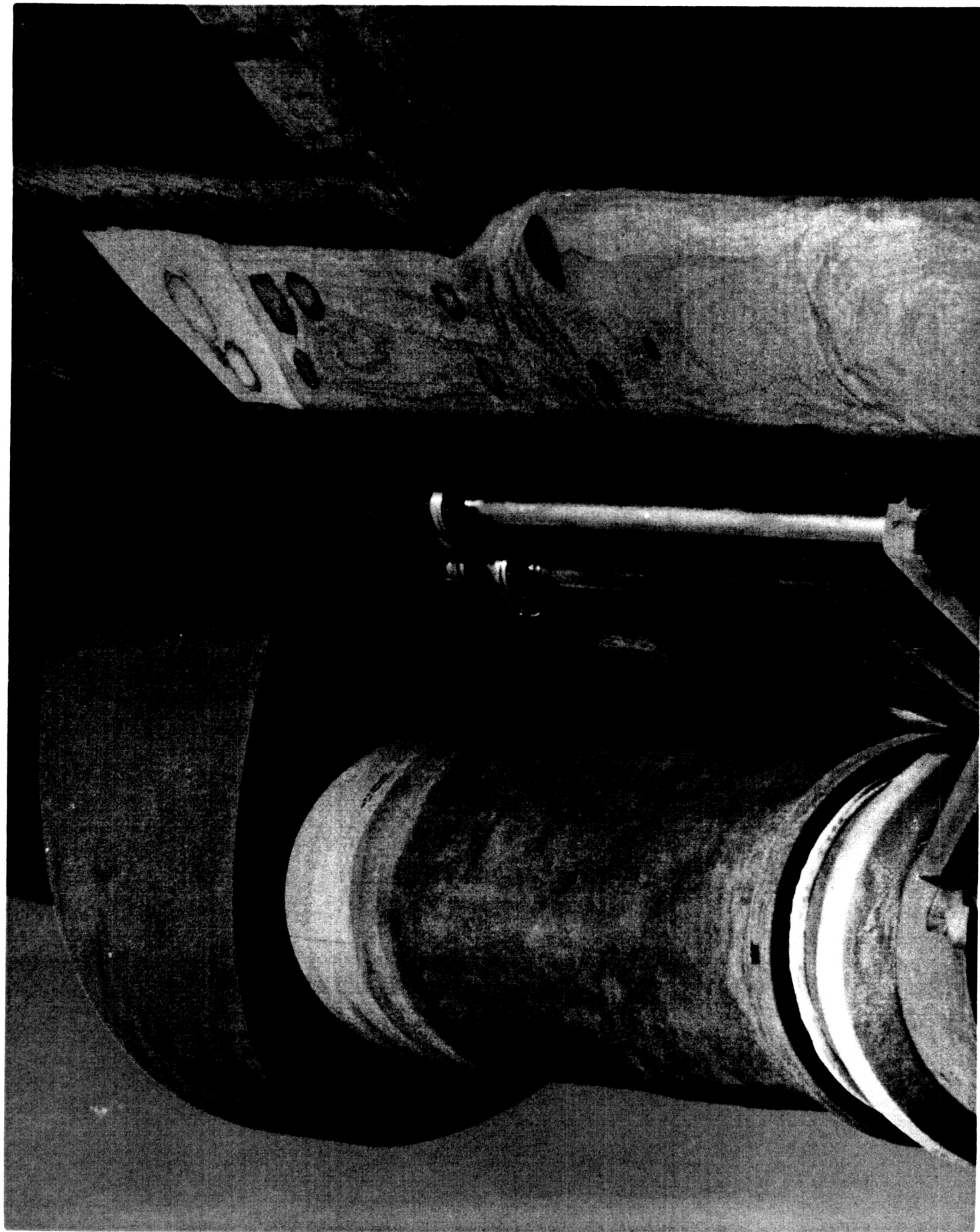
OVERALL VIEW OF VEHICLE FROM SOUTHEAST CORNER OF MLP DECK



DISCOLORED LH FWD RCS PAPER COVER DUE TO RAINWATER INTRUSION

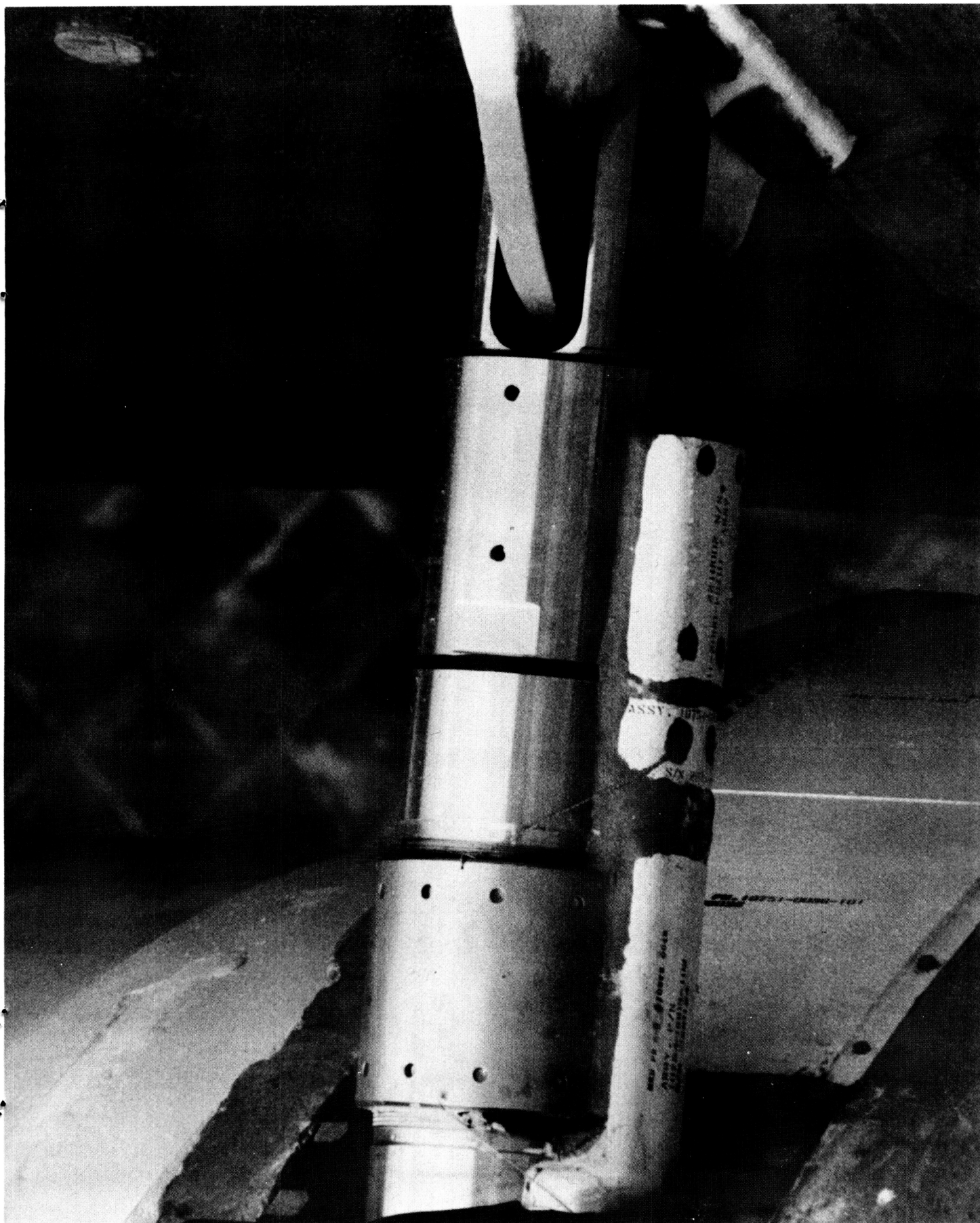


FROST ACCUMULATION AT INTERTANK TO LO2 TANK
INTERFACE FLANGE IN THE -Y-Z QUADRANT



TYPICAL ICE/FROST ACCUMULATION IN
THE LO2 FEEDLINE BELLOWS XT 1106
72

ORIGINAL PAGE
COLOR PHOTOGRAPH



ICE FORMATION ON EB FITTING OUTBOARD TO STRUT PIN HOLE.
ONLY CONDENSATE IS PRESENT ON THE REST OF THE FITTING.



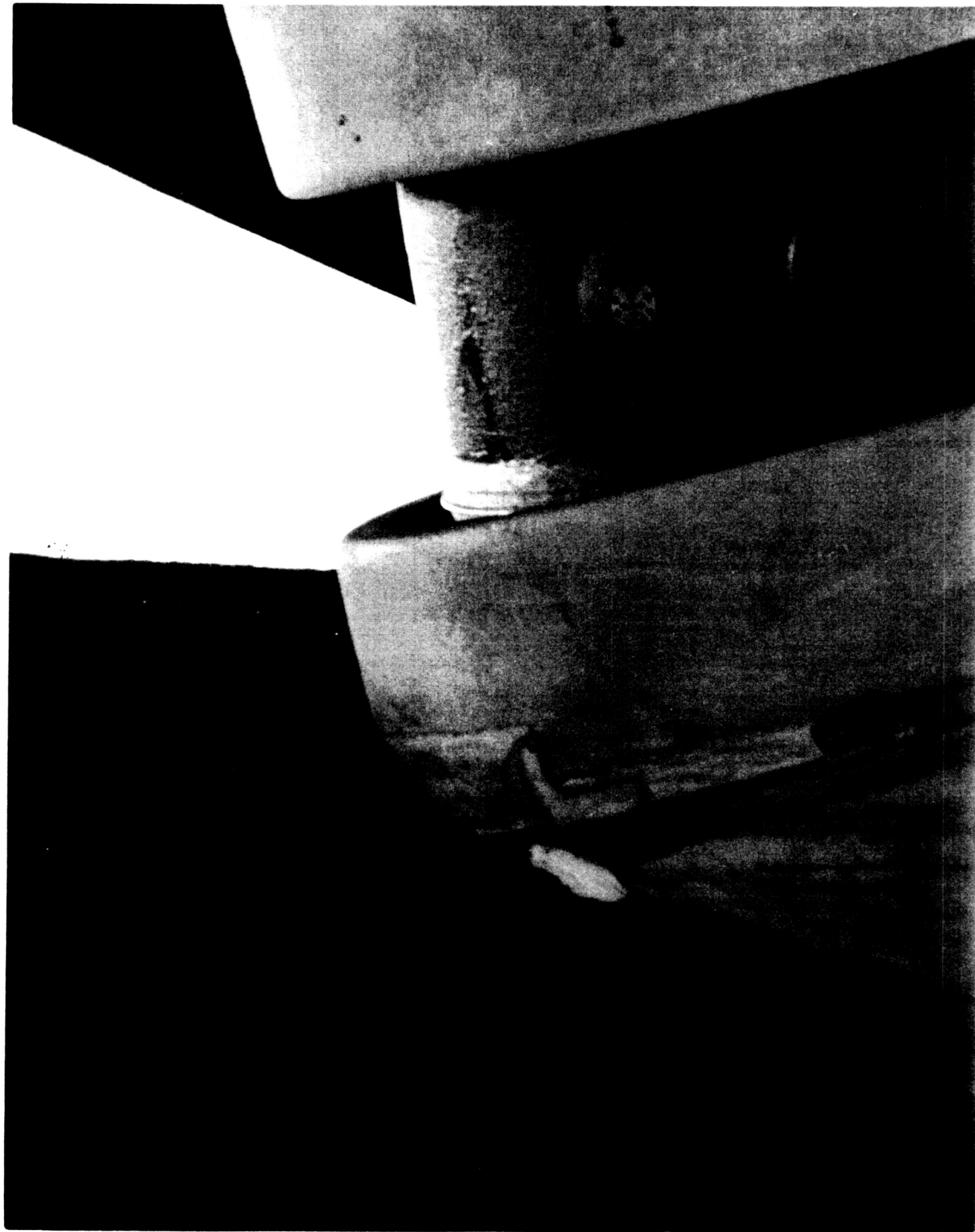
FROST FINGER ON ET/ORB LO2 UMBILICAL PURGE VENT



ICE/FROST ACCUMULATION ON INBOARD AND AFT
PORTIONS OF ET/ORB LO2 UMBILICAL BAGGIE



TYPICAL ICE/FROST ACCUMULATION ON OUTBOARD SIDE OF ET/ORB
LH2 UMBILICAL BAGGIE, ON PURGE VENTS, AND IN BELLOWS ;



FROST SPOT ON EXTERNAL TANK SIDE OF LH2 FEEDLINE



TYPICAL FROST ACCUMULATION IN LH2 FEEDLINE
AND RECIRCULATION LINE BELLOWS



SIX INCH LONG "INVERTED Y" CRACK IN THE MBO-130-149 FOAM ON
THE LH2 UMBILICAL -Z SURFACE NEAR THE RECIRCULATION LINE

7.0 POST LAUNCH PAD DEBRIS INSPECTION

The post launch inspection of the pad and surrounding area was conducted on 4 May 1989 from launch + 3 to 5 hours. The MLP, FSS, pad apron, and acreage areas were inspected except for the flame trench and areas north to the perimeter fence, which were restricted due to high concentrations of HCL. These areas were inspected when the HCL levels subsided the following day. No significant flight hardware or TPS materials were found with the exception of 3 small pieces of SSME nozzle foil insulation blanket material, which may have been trimmings, north of the flame trench. The usual amount of SRB throat plug material (foam and RTV) was present on the pad. Water trough material from the SRB exhaust holes was scattered throughout the field and on the pad apron.

SRB holddown post erosion was negligible for this launch. South holddown post shim material was intact, but had debonded from the shoe sidewall on holddown posts #1 and #2. One frangible nut and four NSI fragments from the holddown post #5 debris container were found on the stud of HDP #5. No recent pieces of frangible nut and NSI fragments were recovered from the holddown post sand boxes during stud removal per OMI B5032. However, one old, rusted NSI fragment and 3 facility fasteners were found in holddown posts # 2, 5, and 6. All of the doghouse blast covers on the north holddown posts were in the closed position and did not appear to be missing any parts. The covers on HDP #3 and #4 exhibited signs of minor erosion on the corners. SRB aft skirt purge lines were in place and undamaged. The SRB joint heater T-0 umbilicals showed no major damage after separation.

Typical facility debris, including sound suppression water trough material, was found at the pad perimeter. The Portable Purge Unit (PPU) electrical connector cover lost from the MLP deck during the launch of STS-29R was recovered. The west lip of the SRB side flame deflector was missing a piece 3'x1'. No evidence of this debris was found on the pad acreage and the piece may have disintegrated as it was pulled loose from the reinforcing metal lattice of the flame deflector surface. Two emergency egress baskets were released after the vehicle cleared the tower. The other five baskets were secured on the FSS 195 foot level and sustained minor launch damage.

The Tail Service Masts, Orbiter access arm, and GOX vent arm showed minimal launch damage. The GH2 vent arm was latched on the fourth tooth of the latching mechanism. No loose cables dangled from the haunch.

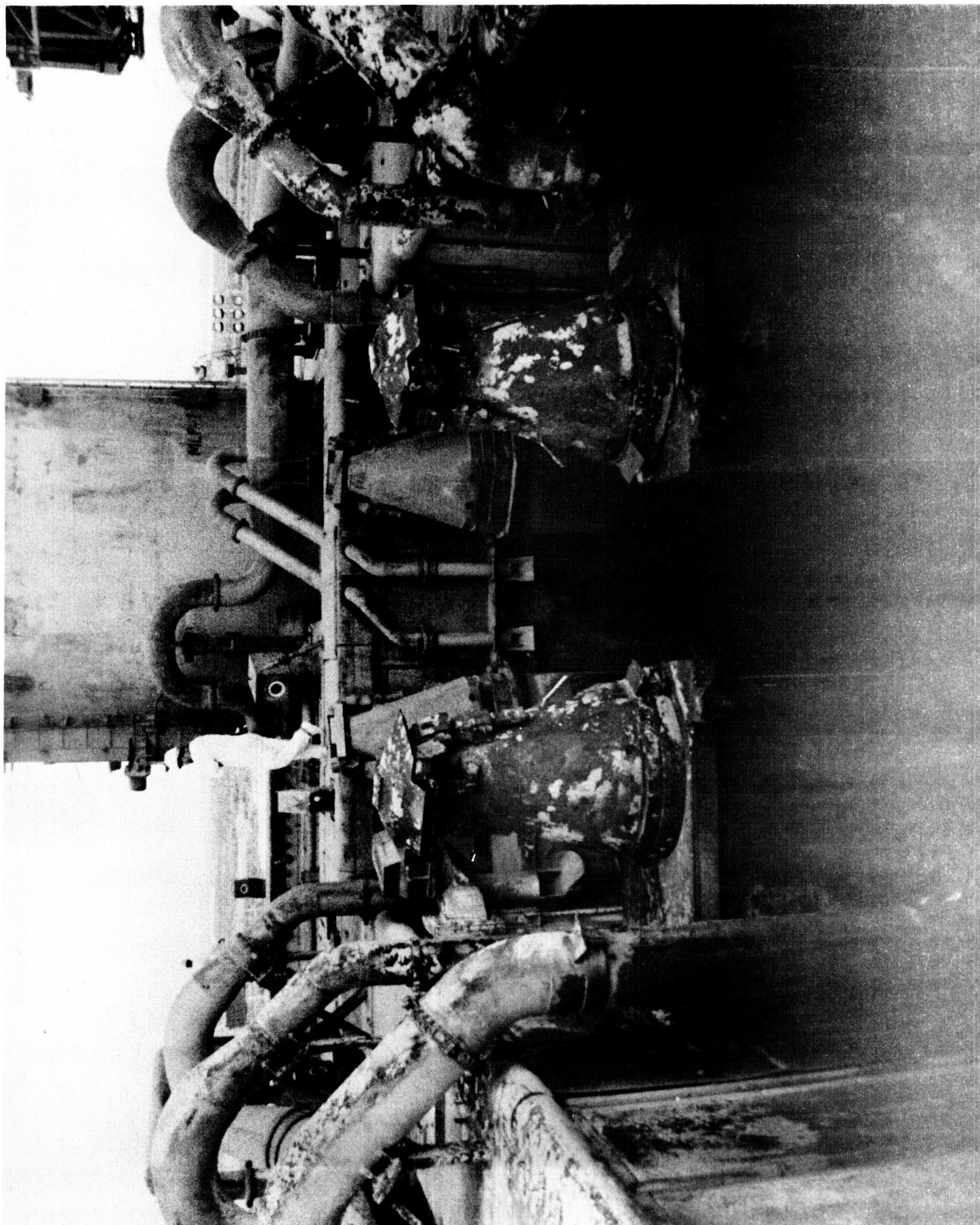
The Shuttle Thermal Imager (STI) units located at Camera Site 2 and on the roof of the RSS sustained no launch damage and were operational after launch.

Overall, there was very little damage to the launch pad.

Patrick AFB and MILA tracking radars had been recalibrated for increased sensitivity during the launch of STS-30R. Although the signals were very weak, 42 objects were detected in the time frame T+178.2 through 284 seconds, well after SRB separation. Of the 42 objects, 15 were observed by two radars and 5 objects were detected by three radars. The radar data cannot provide specific object characteristics, such as size and material type. Although all the signals were weak (nonmetallic), 9 of the signals were approximately 4X stronger than the rest of the field and occurred at T + 140.5, 142.4, 150.1, 155, 156.5, 165.7, 174.5, 244, and 250 seconds.

The debris inspection continued on 5 May 1989 and was expanded to include areas outside the pad perimeter fence. Ground teams searched the beach, railroad tracks, and beach road from the northern KSC boundary to the Titan complex. The NASA helicopter was utilized to cover the inaccessible areas around the pad, the beach from the Cape lighthouse to a point 10 miles north of the pad, and ocean area under the flight path. No flight hardware was found.

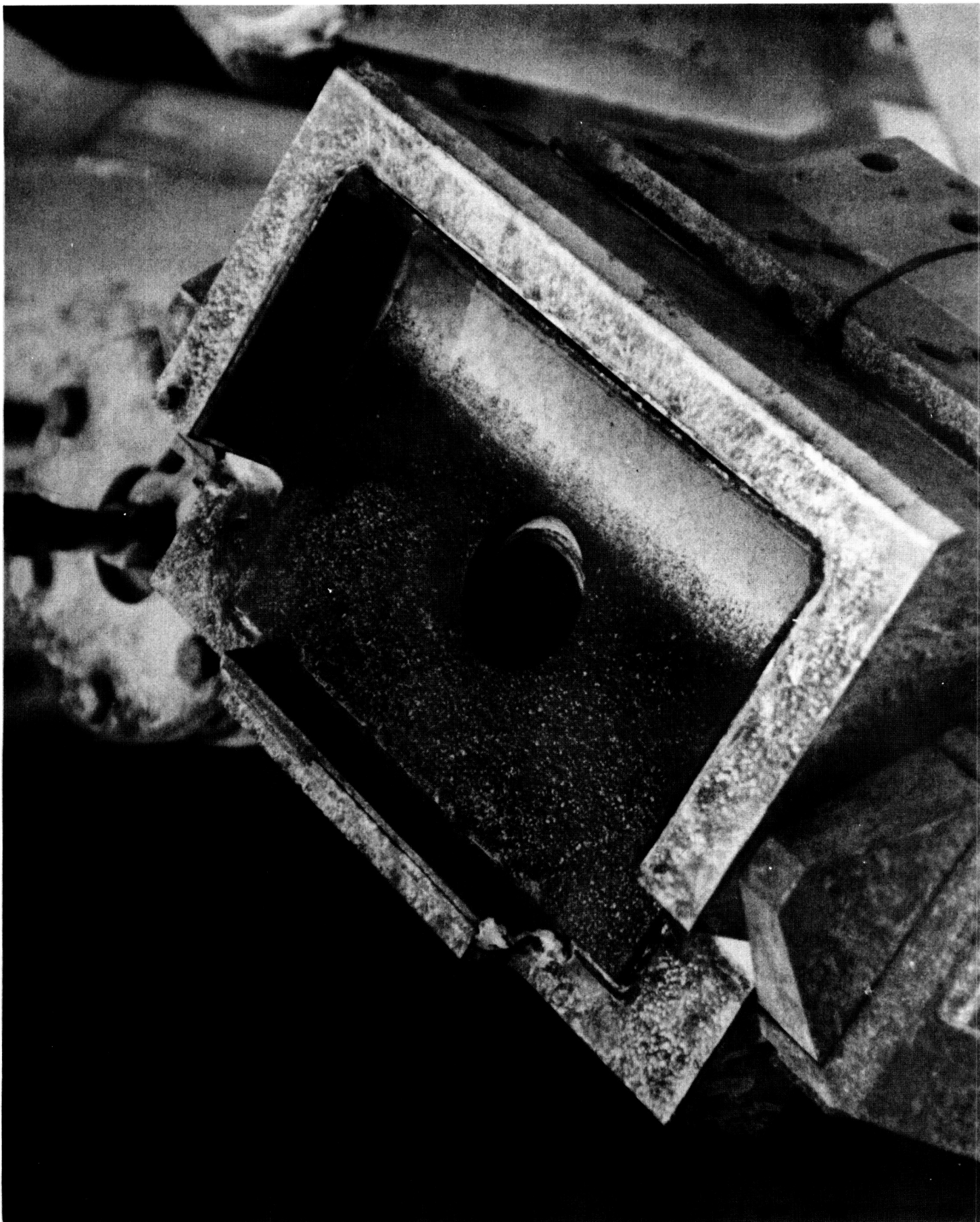
There were no facility Post Launch Anomalies.



OVERALL VIEW OF LH SRB HOLDDOWN POSTS



NEGLIGIBLE NORTH HOLDDOWN POST EROSION



SOUTH HOLDDOWN POST SHIM MATERIAL
INTACT BUT DEBONDED FROM SIDEWALL



FRANGIBLE NUT AND NSI FRAGMENTS FOUND IN HDP #5 STUD HOLE



ORIGIN OF MATERIAL FOUND ON MLP DECK
IS UNKNOWN BUT IS NOT DECK COATING

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ORIGINAL PAGE
COLOR PHOTOGRAPH

8.0 LAUNCH FILM SUMMARY/PROBLEM REPORT DISPOSITION

A total of 132 film and video data items, which included 40 videos, 55 16mm films, 28 35mm films, 7 70mm films, and 1 special film were reviewed starting on Launch day.

No major vehicle damage or lost flight hardware was observed that would have affected the mission. However, A 6"x3"x1" piece of black tile from the body flap hinge area near SSME #3 was shaken loose during SSME ignition (E-5, 15, 19, 20, 76, 77, OTV 155). Some tiles on the base heat shield were chipped by main engine acoustics (E-19, 23, 24), but this area in general sustained less damage than usual during SSME startup.

The hat band #7 thermal insulation blanket on SSME #1 came loose during ignition (E-19, 76).

A heavy shower of ice and frost particles from the ET/ORB LH2 and LO2 umbilicals falls past the body flap during SSME ignition, but no Orbiter tile damage is visible (E-4, 6, 16, 18, 31, 48, 65, OTV 163).

A thin, 4"x3" piece of light-colored material, possibly TPS trimming, appears from the ET intertank area, floats down past the bipods, and contacts the Orbiter twice on the RH forward lower surface. No apparent tile damage resulted. Four ice particles appear from the same area above the bipods, but do not impact the Orbiter. Eight pieces of ice from the upper ET LO2 feedline bellows area fell along the lower left surface of the Orbiter (from the right side), but did not appear to contact the Orbiter (E-34, 35, 36, 41).

Frangible nut and NSI fragments continue to be lost from the holddown post debris containers. Seven pieces fall from the HDP #5 stud hole (E-12, EX4) and two pieces from HDP #2 (E-8).

Just after liftoff, a 25-inch length of rope-like material, possibly a string of RTV with pieces of RCS paper cover attached, flaps on the -Z side of the RH OMS stinger (E-2, 5, 19, 25). It appears to fall off by 100 feet of vehicle rise.

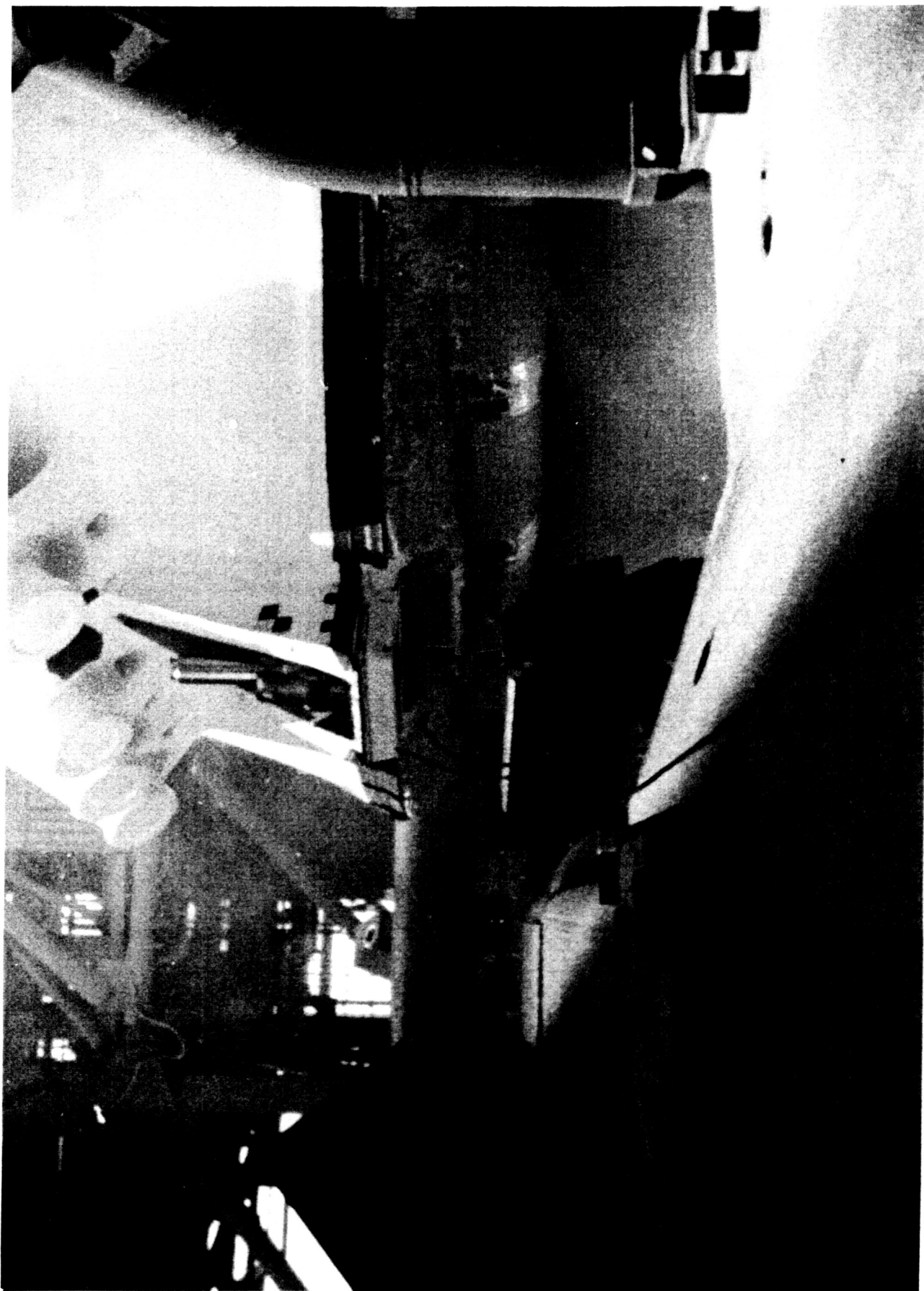
Numerous pieces of debris from the vehicle are visible during ascent. Most have been identified as ice/frost particles from the ET/ORB umbilicals, RCS paper covers from the Orbiter, instafoam particles from the SRB aft skirt, and pieces of foam from the ET intertank area (E-53, 59, 60, 203, 220, 221, 222, 223, MAG 60).

Many film and video items record various amounts of flying debris on the pad after the vehicle has cleared the tower. This debris is SRB throat plug material and shredded sound suppression water troughs - an expected occurrence.

There were no major facility anomalies. No swing arms or other pad structures contacted the vehicle during liftoff. The emergency egress slidewire baskets found in the landing zone did not release from the FSS 195 foot level during the time period from SSME ignition through tower clear (E-57, 58, 63, 64, OTV 171).

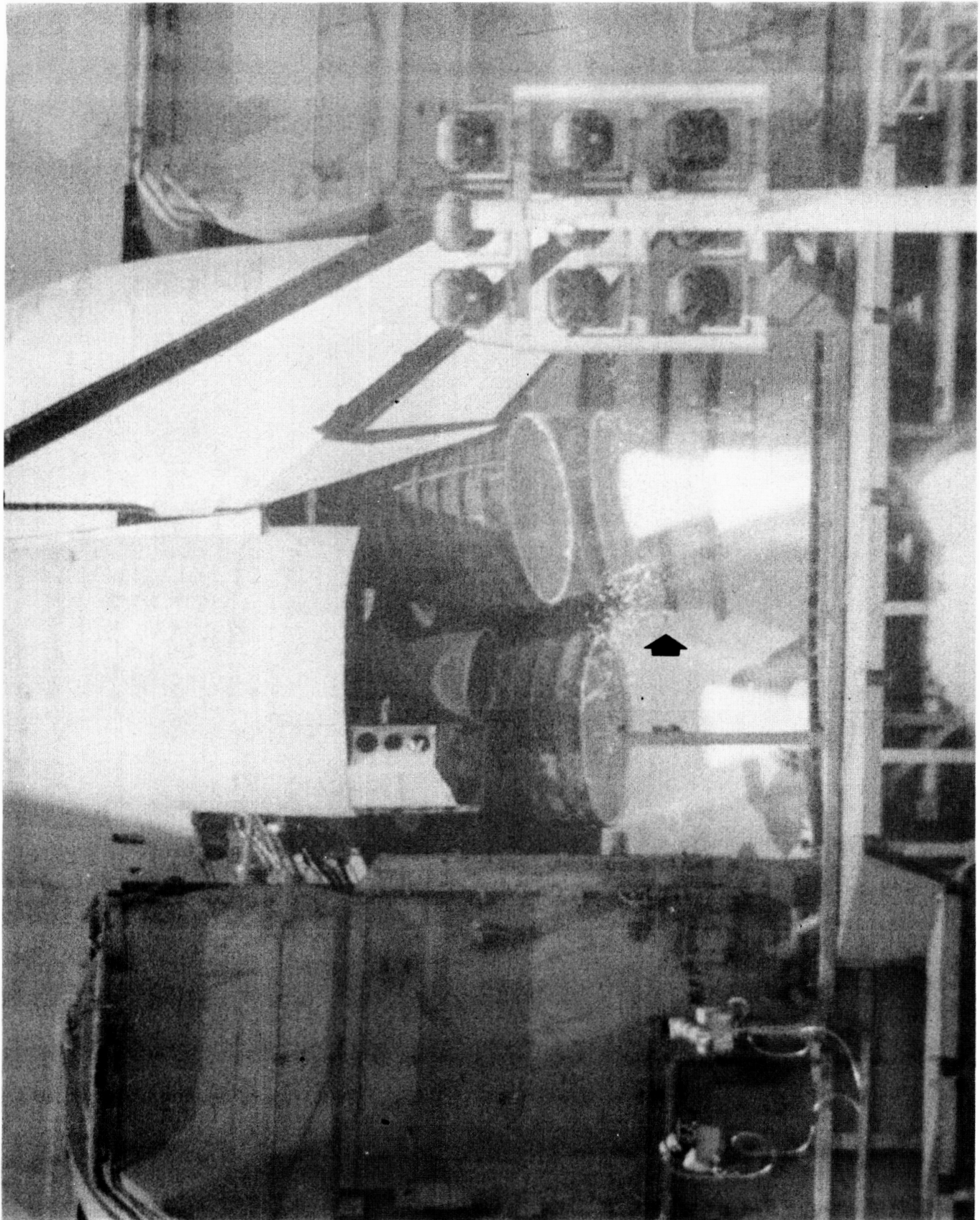
During the Orbiter's final approach for landing, a thin, white, low density object first appears in the vicinity of the LH OMS pod and is swept aft by the airstream (approximately 17 seconds prior to landing gear deployment). Since no white tiles or AFRSI panels were missing, this was most likely a piece of the thermal barrier from the SSME horsecollar (E-1005, 1008).

No PR's or IPR's were generated as a result of the launch film and video data review. Observed Post Launch Anomalies are listed in Section 12.0.



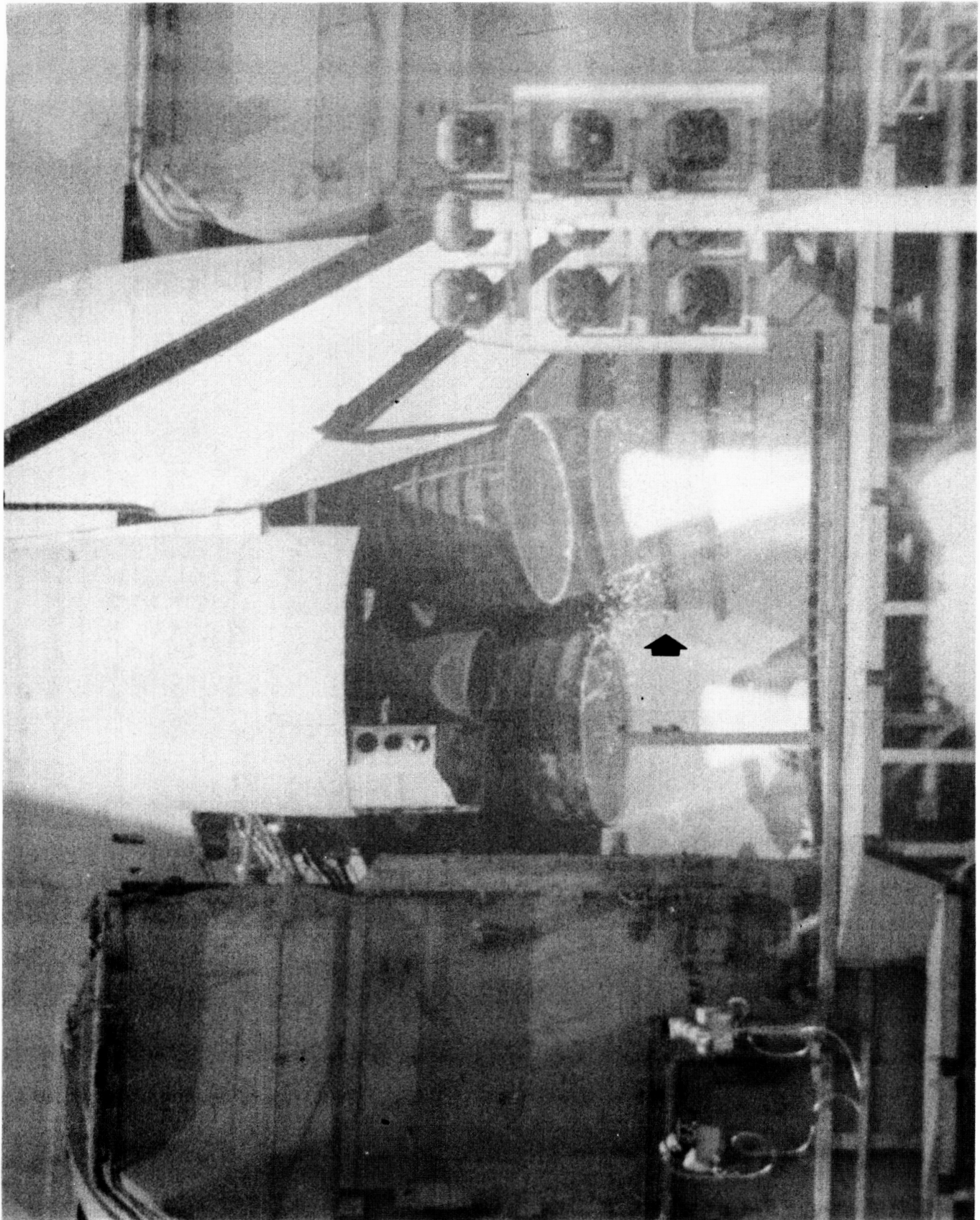
FRANGIBLE NUT AND NSI FRAGMENTS DROP FROM THE
SRB AFT SKIRT HOLDDOWN POST #5 STUD HOLE

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

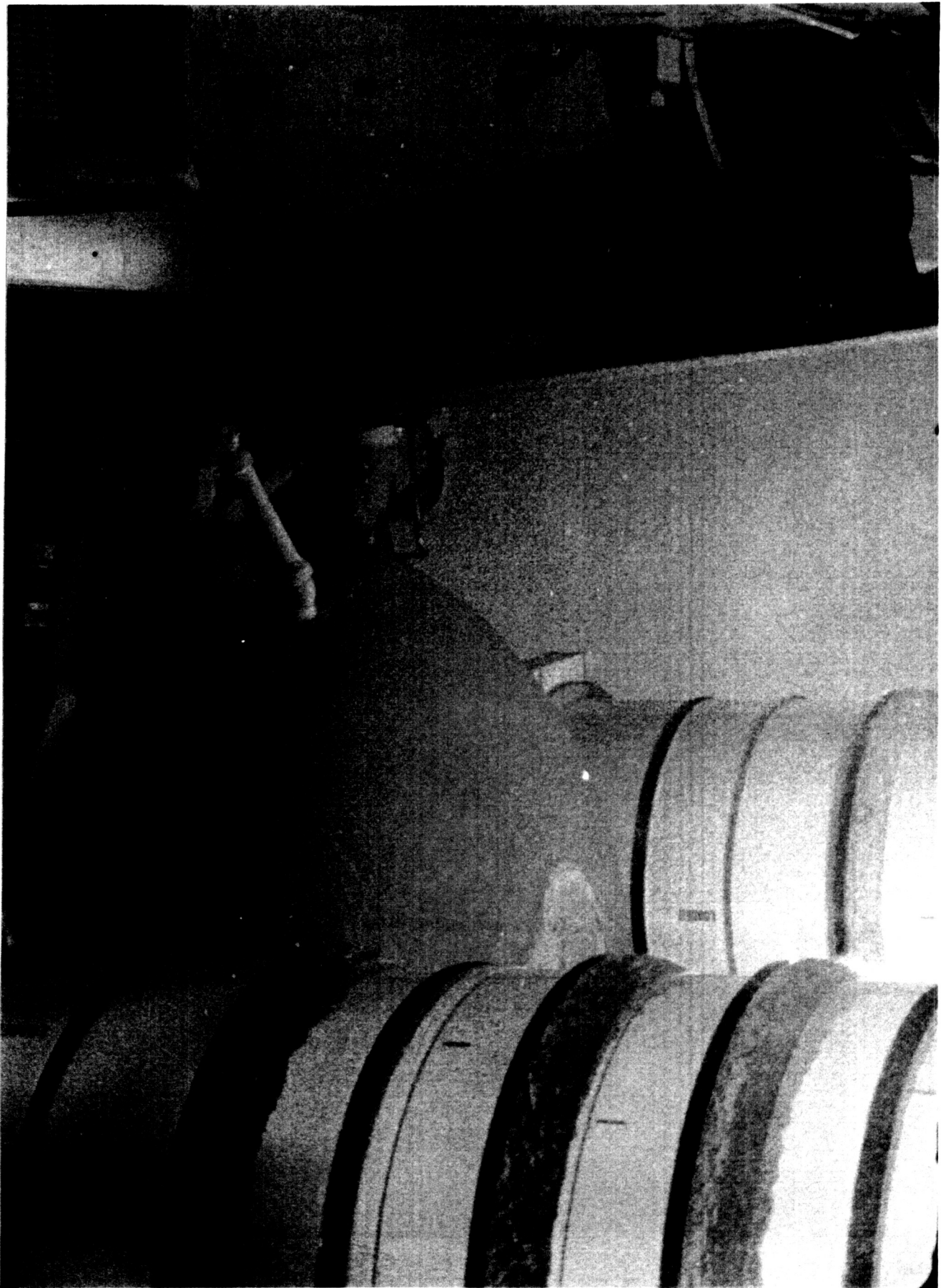


PIECE OF BLACK TILE FROM BODY FLAP
HINGE AREA FALLS PAST SSME #3 NOZZLE
90

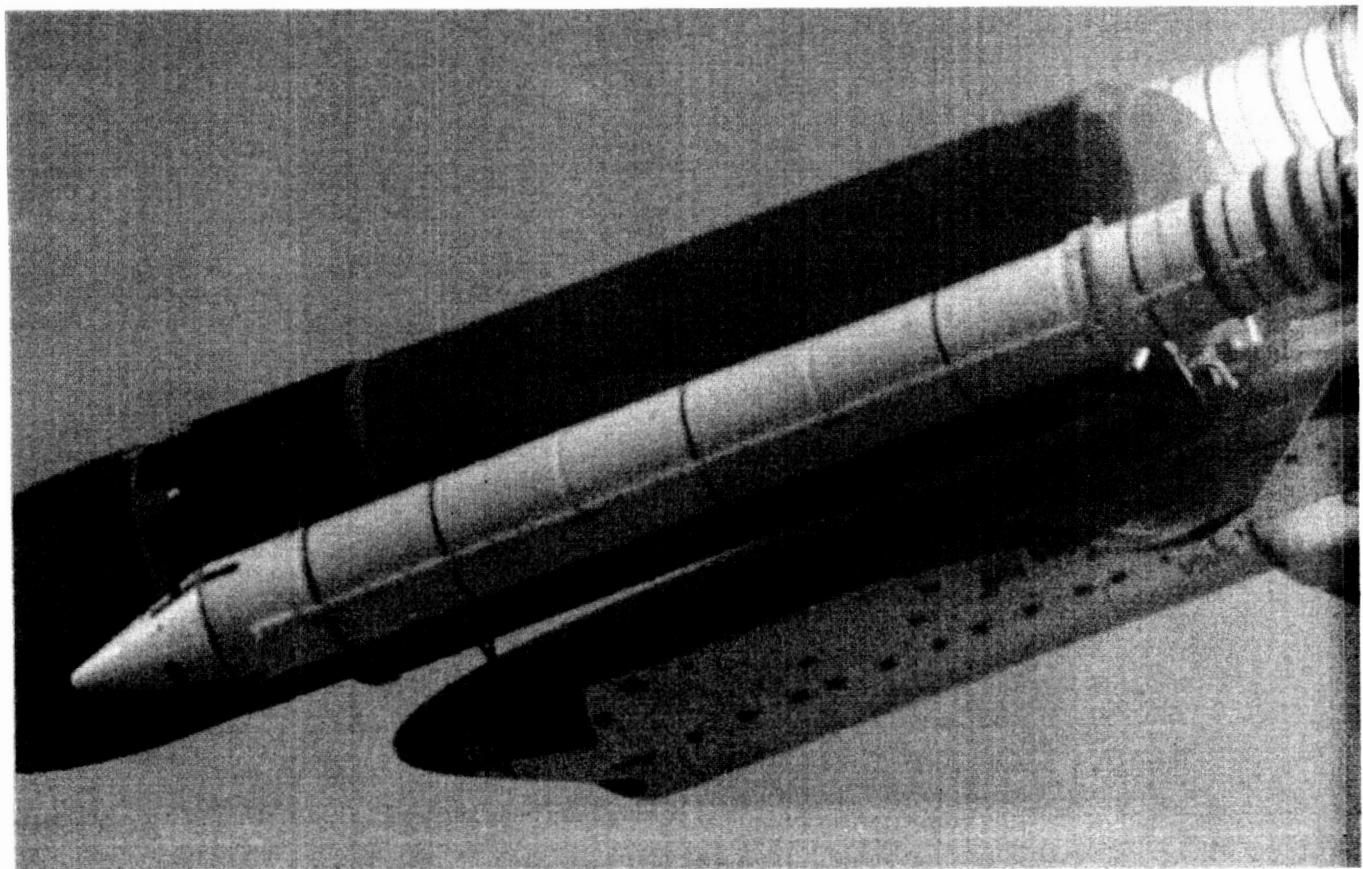
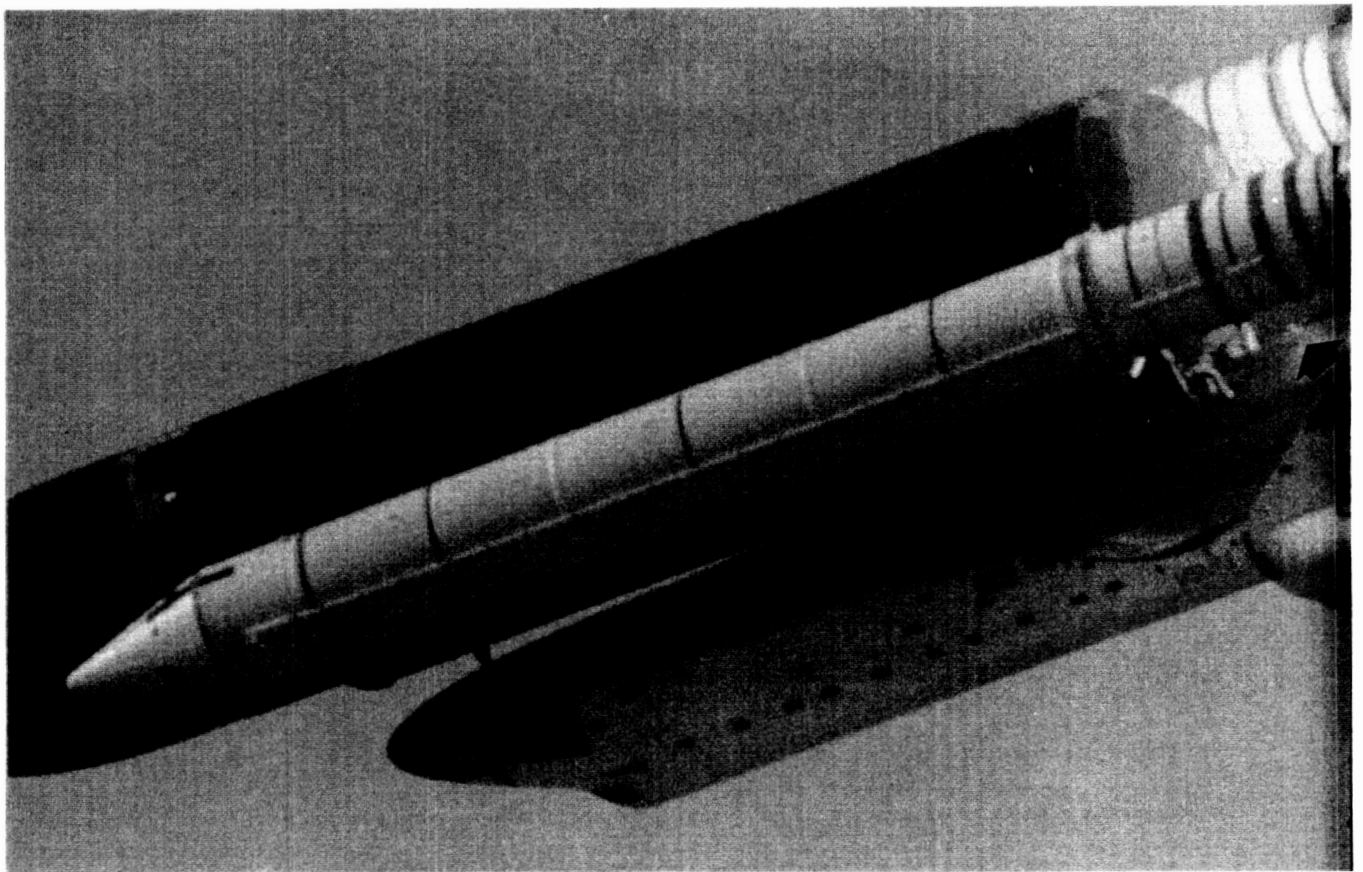
ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH



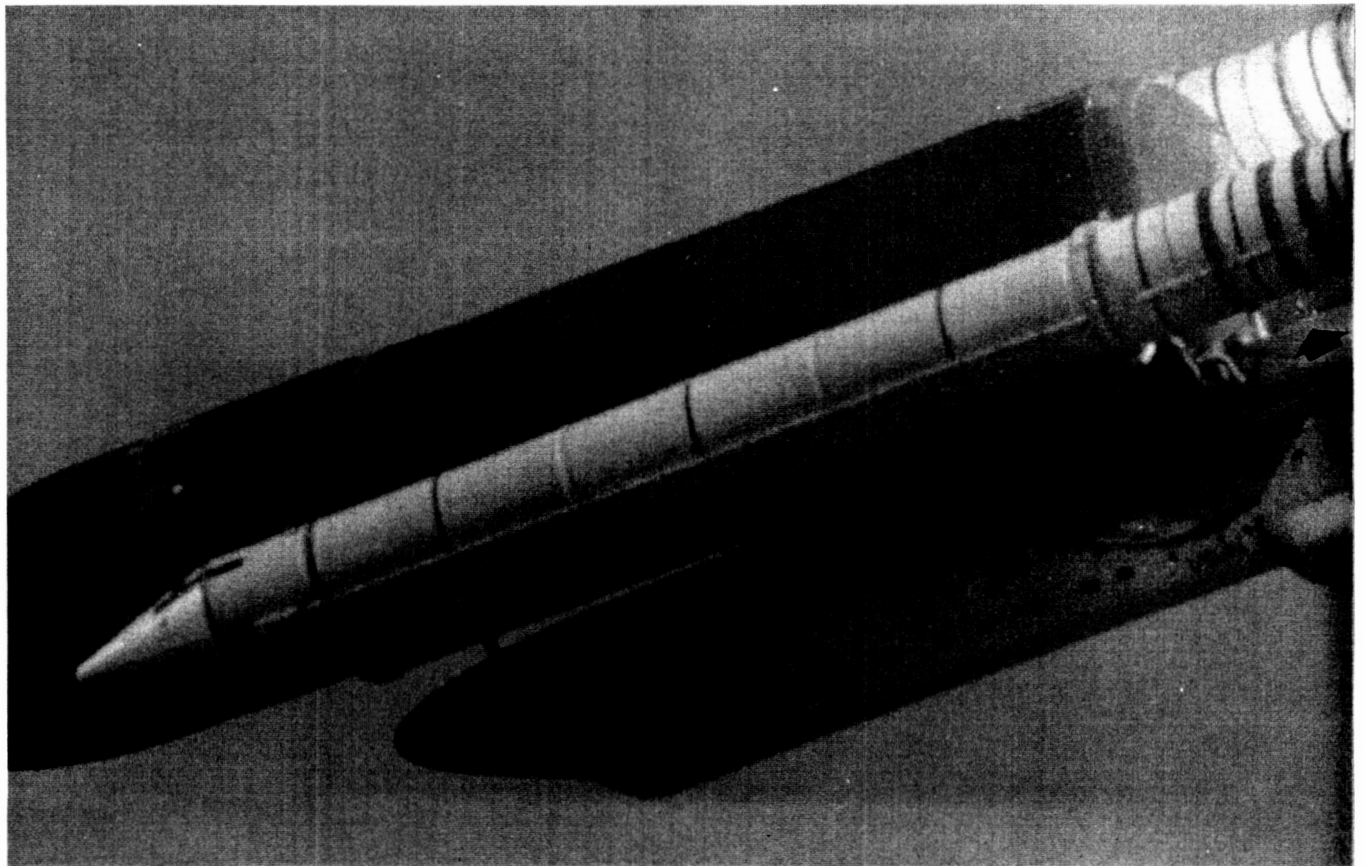
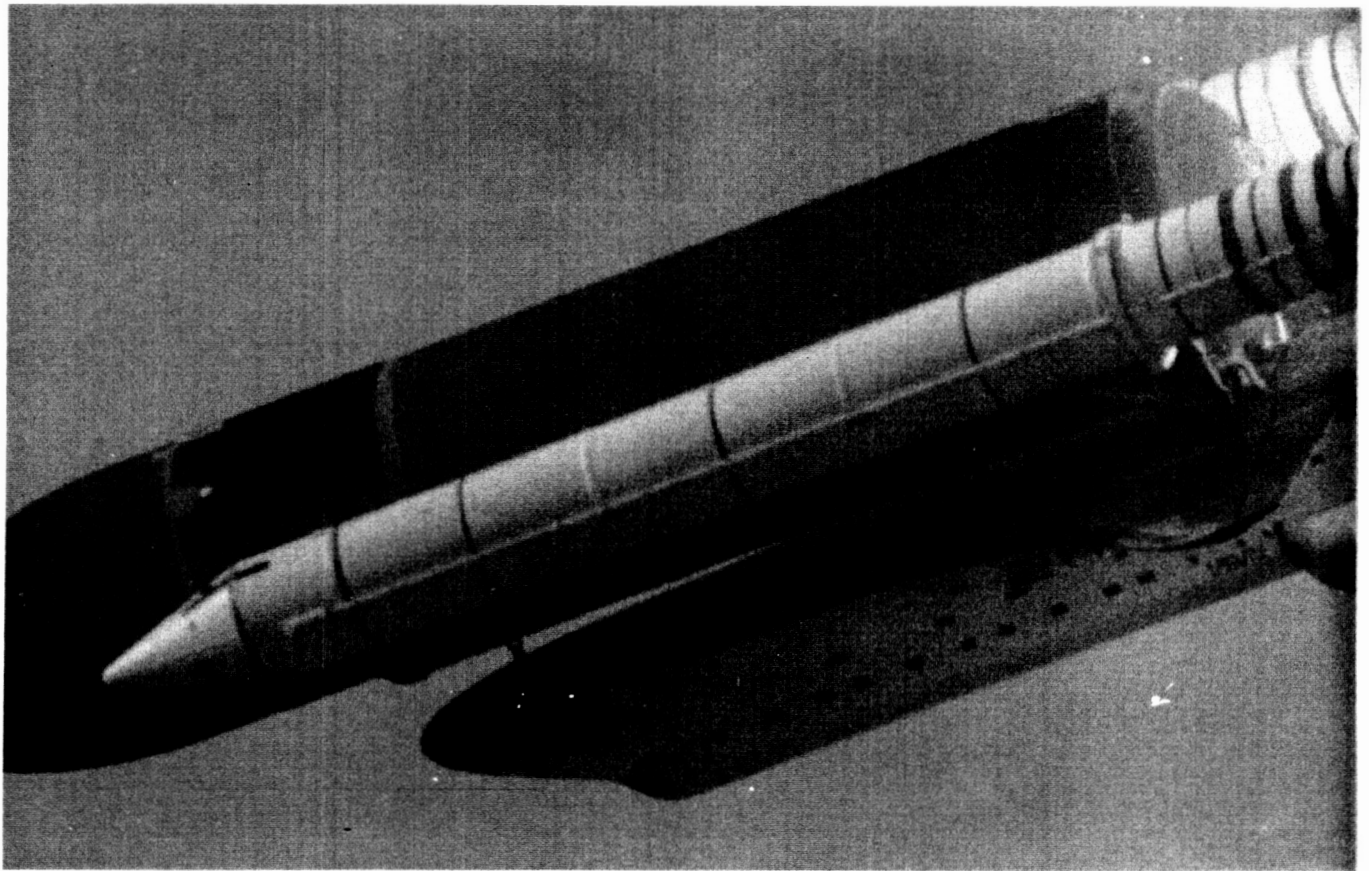
PIECE OF BLACK TILE FROM BODY FLAP
HINGE AREA FALLS PAST SSME #3 NOZZLE
90



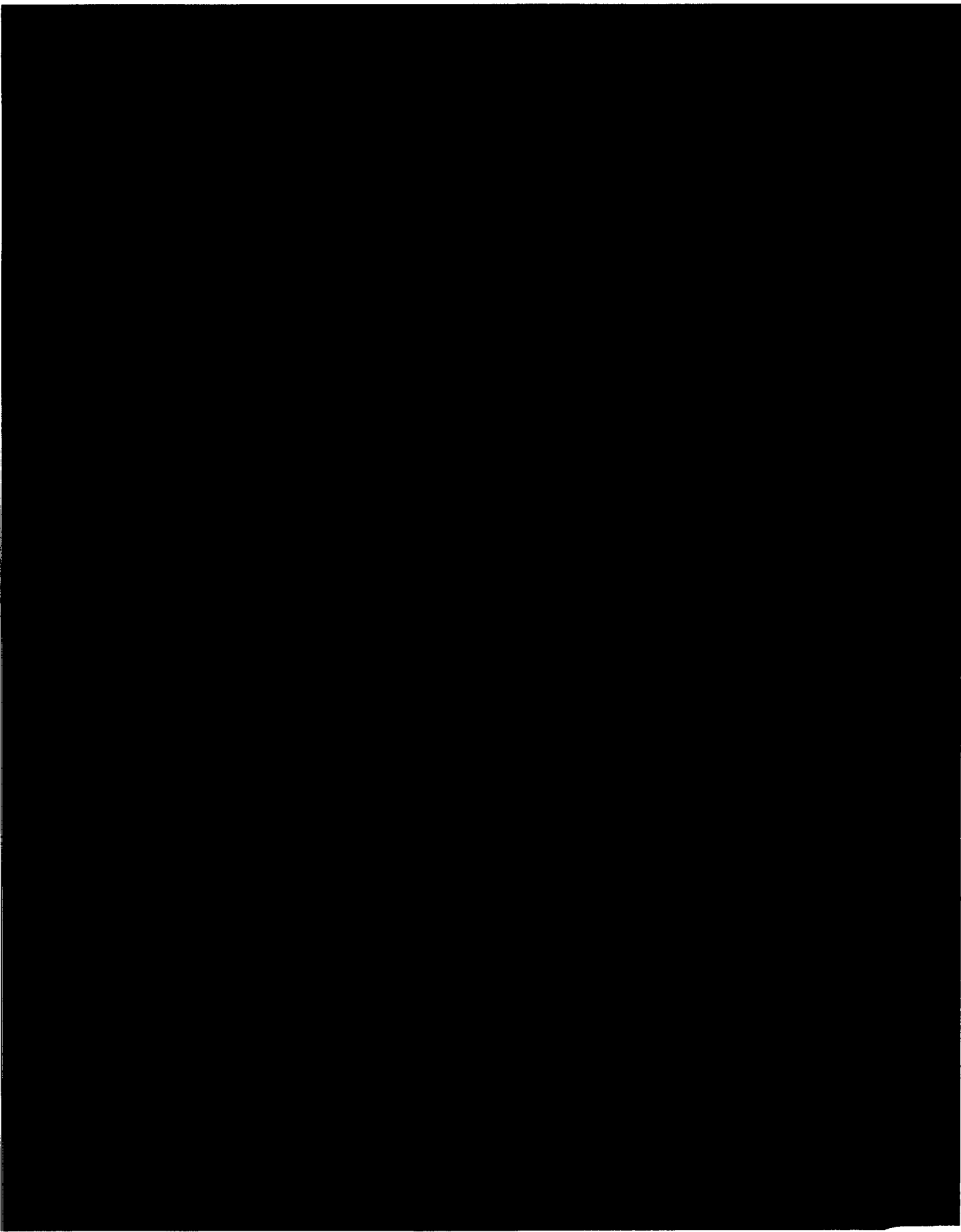
ICE/FROST FALLS FROM ET/ORBITER UMBILICALS.
NO UNUSUAL VAPORS EMANATE FROM LH2 UMBILICAL.



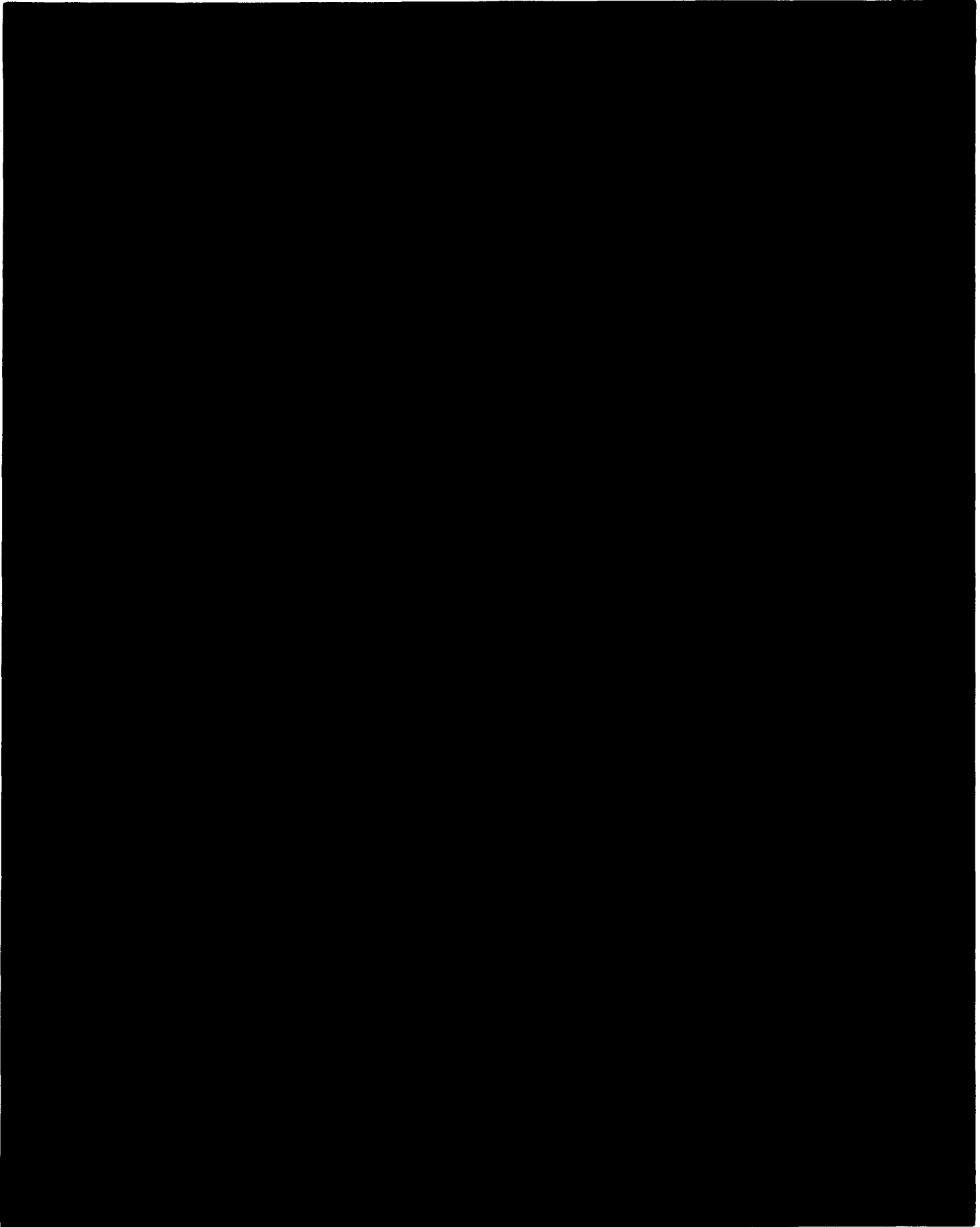
SHORTLY AFTER ROLL MANEUVER, A LARGE PIECE OF LH2 UMBILICAL BAGGIE WITH ICE ATTACHED FALLS AFT. NO TILE DAMAGE VISIBLE.



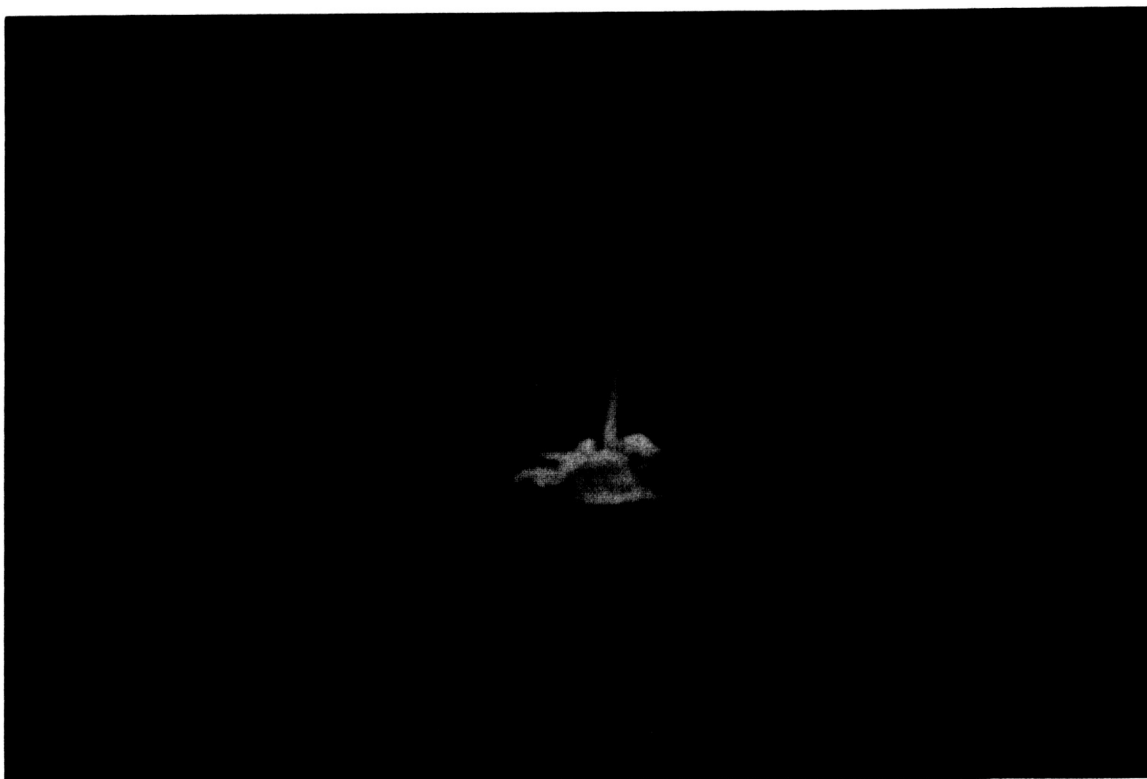
SHORTLY AFTER ROLL MANEUVER, A LARGE PIECE OF LH2 UMBILICAL BAGGIE WITH ICE ATTACHED FALLS AFT. NO TILE DAMAGE VISIBLE.



SHORTLY AFTER ROLL MANEUVER, FORWARD RCS PAPER COVERS COME
LOOSE AND FALL AFT WITHOUT STREAKING ORBITER WINDOWS



CLEARLY DEFINED BSM PLUMES DURING SRB SEPARATION



PIECE OF WHITE THERMAL BARRIER FROM SSME HORSE COLLAR
SEPARATES FROM ORBITER DURING FINAL APPROACH

8.1 POST-LAUNCH FILM AND VIDEO REVIEW

EX1 Camera is located on MLP deck south of RH SRB
400 FPS exhaust duct and looks north to view RH SRB Heater
16mm Umbilical during ignition and liftoff.

Focus : SOFT
F. O. V.: OK
Exposure: SLIGHTLY UNDEREXPOSED

Comments: VERY SMALL PIECES OF FACILITY DEBRIS FLOAT OUT OF EXHAUST HOLE DURING SSME IGNITION. T-0 OCCURS AT FRAME 4372. AS PYROS FIRE, A 1/2-INCH PARTICLE APPEARS FROM BEHIND BASE OF DEBRIS CONTAINER AND HEADS UPWARD IN GENERAL DIRECTION OF BODY FLAP. NO JOINT HEATER UMBILICAL ANOMALIES. NO FRANGIBLE NUT OR NSI FRAGMENTS DROP FROM AFT SKIRT STUD HOLE. HOLDDOWN POST SHOE SHIM IS INTACT. SMALL PIECES OF AFT SKIRT INSTAFOAM (LARGEST 3"X2") FALL FROM VEHICLE DURING ASCENT. OTHER PIECES ARE THROAT PLUG MATERIAL. SRB THERMAL CURTAIN TAPE IS ATTACHED.

EX2 Camera is located on the MLP deck west of RH SRB
400 FPS flame duct and looks east to view SRB Heater
16mm Umbilical during ignition and liftoff.

Focus : OK
F. O. V.: UMBILICAL NOT CENTERED
Exposure: OK

Comments: SEVERAL SMALL PIECES OF INSTAFOAM ORIGINATE FROM UNDER AFT SKIRT DURING SSME STARTUP. NUMEROUS SMALL PIECES OF FACILITY DEBRIS ARE DRAWN ACROSS MLP DECK BY SSME ASPIRATION. UMBILICAL BEGINS TO DISCONNECT AT FRAME 4283 AND SEPARATION APPEARS NOMINAL. T-0 OCCURS AT FRAME 4314. A RED-COLORED OBJECT 6"X4"X1/4", POSSIBLY RTV, APPEARS FROM AROUND SIDE OF SRB AS VEHICLE LEAVES FOV.

EX3 Camera is located on the MLP deck east of LH SRB
400 FPS flame duct and looks west to view SRB Heater
16mm Umbilical during ignition and liftoff.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: SMALL PIECES OF FACILITY DEBRIS AND MLP DECK SCALE ARE DRAWN ACROSS MLP DECK BY SSME ASPIRATION. A 1/2-INCH PARTICLE OF ICE HITS BLUE VELCRO STRIP ON AFT SKIRT AND BREAKS INTO SMALLER

PIECES - NO DAMAGE TO VEHICLE. T-0 OCCURS AT 4304. JOINT HEATER UMBILICAL DISCONNECT AND SEPARATION ARE NOMINAL. SMALL PIECES OF AFT SKIRT INSTAFOAM AND SRB THROAT PLUG MATERIAL ARE KICKED UP OUT OF FLAME HOLE AT SRB IGNITION.

EX4 Camera is located on MLP deck south of LH SRB
400 FPS flame duct and looks north to view LH SRB Heater
16mm Umbilical during ignition and liftoff.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: A SHOWER OF WATER DELUGE DROPLETS AND SOME SMALL ICE PARTICLES FROM THE LH2 UMBILICAL FALL THROUGH THE FOV DURING SSME STARTUP. T-0 OCCURS AT FRAME 4157. AS THE VEHICLE BEGINS TO RISE, A LARGE FRANGIBLE NUT (FRAME 4327) AND TWO SMALL NSI FRAGMENTS (FRAME 4359) FALL FROM AFT SKIRT STUD HOLE INTO HOLDDOWN POST. FOUR MORE PIECES FALL AT FRAMES 4445, 4451, 4462, AND 4473. FIVE OF THE PIECES DROPPED INTO THE STUD HOLE OF THE HOLDDOWN POST, TWO FELL INTO THE FLAME HOLE.

E-1 Camera is located on the NE corner of the MLP deck
400 FPS and views the lower ET, SRB's, and Orbiter.
16mm

Focus : GOOD
F. O. V.: GOOD
Exposure: GOOD

Comments: FACILITY WATER DELUGE IMPINGES ON LH SRB. SSME START SEQUENCE INITIATED AT FRAME 4822. DURING SSME IGNITION, 8 ICE PARTICLES FALL FROM ET/ORB LH2 UMBILICAL (FRAME 5050). SRB T-0 OCCURS AT FRAME 6165. APPROXIMATELY 18 MORE PIECES OF ICE, THE LARGEST ESTIMATED AT 5"X4", FALL FROM THE LH2 UMBILICAL AFTER T-0. NONE APPEAR TO CONTACT THE VEHICLE. DURING LIFTOFF AND ASCENT, NO VAPORS EMANATE FROM THE ET/ORB LH2 UMBILICAL.

E-2 Camera is located on the SE corner of the MLP deck
400 FPS and views Orbiter SSME and OMS engine nozzles.
16mm

Focus : GOOD
F. O. V.: GOOD
Exposure: GOOD

Comments: SSME IGNITION SEQUENCE INITIATED AT FRAME 3801. RH RCS
STINGER PAPER COVERS SHED FROM FRAME 4252 THROUGH 5047. T-0
OCCURS AT FRAME 6593. A 25-INCH LENGTH OF ROPE-LIKE MATERIAL,
POSSIBLY A STRING OF RTV WITH PIECES OF RCS PAPER COVER ATTACHED,
FLAPS ON THE -Z SIDE OF THE RH OMS STINGER FROM FRAME 7599
THROUGH LOV. SRB THERMAL CURTAIN TAPE IS INTACT. CONDENSATE FROM
ET AFT DOME AND WATER FROM SRB STIFFENER RINGS VAPORIZES.

E-3 Camera is located on the SW corner of the MLP deck
400 FPS and views Orbiter SSME and OMS engine nozzles.
16mm

Focus : SOFT
F. O. V.: GOOD
Exposure: GOOD

Comments: SSME IGNITION SEQUENCE INITIATED AT FRAME 2079. RCS
PAPER COVERS RUPTURE AND SEPARATE (FRAMES 2318 - 2764). TWO SMALL
PARTICLES DROP FROM THE BASE HEAT SHIELD AREA NEAR THE SSME #3
NOZZLE (FRAME 3366). A 3"X2" PARTICLE OF ICE FALLS FROM THE
ET/ORB UMBILICAL (FRAME 3950). T-0 OCCURS AT FRAME 4320. LH SRB
THERMAL CURTAIN TAPE IS INTACT. CONDENSATE FROM ET AFT DOME AND
WATER FROM SRB STIFFENER RINGS VAPORIZES.

E-4 Camera is located on the NW corner of the MLP deck
400 FPS and views lower ET, SRB's, and Orbiter.
16mm

Focus : GOOD
F. O. V.: GOOD
Exposure: SLIGHTLY UNDEREXPOSED

Comments: SSME IGNITION SEQUENCE INITIATED AT FRAME 2789. AT
LEAST 21 PIECES OF ICE FALL FROM THE ET/ORB LO2 UMBILICAL DURING
THE TIME FRAME 3626 THROUGH 4829. T-0 OCCURS AT FRAME 4829.
RESIDUAL LOX CAUSES A VAPOR CLOUD AROUND THE LOX TSM UMBILICAL
AFTER DISCONNECT. ONE PIECE OF ICE FALLS FROM THE ET/ORB UMBILI-
CAL AFTER T-0. CONDENSATE FROM THE ET AFT DOME AND WATER FROM THE
SRB STIFFENER RINGS VAPORIZES. THE AMOUNT OF VAPORS IS NOMINAL
AND SHOULD NOT BE CONSIDERED HYDROGEN.

E-5 Camera is located on the east side of the MLP
400 FPS deck and views the Orbiter RH wing, body flap,
16mm and lower ET/SRB.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: SSME IGNITION SEQUENCE INITIATED AT FRAME 2025. A
6"X3"X1" PIECE OF TILE FROM THE BODY FLAP HINGE AREA FALLS
BETWEEN THE BODY FLAP AND SSME #3 NOZZLE (FRAME 2926 THROUGH
3127). T-0 OCCURS AT FRAME 4176. SEVERAL PIECES OF ICE FALL FROM
THE ET/ORB LO2 AND LH2 UMBILICALS. THE 25-INCH PIECE OF ROPE-LIKE
MATERIAL (REF E-2) IS ATTACHED TO THE RCS THRUSTER AT FRAME 4795
AND APPEARS TO FALL OFF BY 100 FEET OF VEHICLE RISE AT FRAME 5149
(REF E-65).

E-6 Camera is located on the east side of the MLP deck
200 FPS and views the RH lower Orbiter wing, body flap, ET
16mm lower LOX feedline, and ET/Orbiter umbilical area.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: SSME IGNITION BEGINS AT FRAME 1347. THE TILE PIECE
FALLING FROM THE BODY FLAP HINGE AREA OBSERVED IN SEVERAL OTHER
FILM ITEMS IS NOT VISIBLE IN THIS ITEM. T-0 OCCURS AT FRAME 2361.
ICE AND FROST PARTICLES FALL FROM BOTH ET/ORB UMBILICALS, BUT NO
DAMAGE TO ORBITER TILES IS APPARENT. NO UNUSUAL VAPORS EMANATE
FROM THE ET/ORB LH2 UMBILICAL.

E-7 Camera is located on the MLP deck and views the
400 FPS RH SRB northeast holddown post (HDP #4).
16mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: SMALL DARK OBJECT, PROBABLY FACILITY DEBRIS, LANDS ON
MLP DECK NEAR CAMERA (FRAME 2091) DURING SSME IGNITION. WATER IS
LEAKING FROM A JOINT IN THE WATER DELUGE SYSTEM. T-0 OCCURS AT
FRAME 4112. SMALL DARK PIECES OF DEBRIS APPEAR OUT OF FLAME HOLE
SHORTLY AFTER T-0. CLOSING OF HOLDDOWN POST DOGHOUSE BLAST COVER
IS NOMINAL.

E-8 Camera is located on the MLP deck and views the
400 FPS RH SRB southeast holddown post (HDP #2).
16mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: SSME IGNITION OCCURS AT FRAME 2214 FOLLOWED BY T-0 AT
FRAME 4201. A SMALL PIECE OF DEBRIS MATERIAL IS DRAWN ACROSS MLP
DECK AND INTO FLAME HOLE (FRAME 4291). SEVERAL PIECES OF SRB
THROAT PLUG MATERIAL APPEAR IN FOV. TWO PIECES OF SHRAPEL, 2
INCHES AND 3 INCHES LONG, RESPECTIVELY, ARE KICKED UP OUT OF
FLAME HOLE, BUT DOES NOT CONTACT VEHICLE. HOLDDOWN POST SHOE
ROCKS VIOLENTLY AND REMAINS COCKED AT APPROXIMATELY 3 DEGREES AS
VEHICLE LEAVES FRAME.

E-9 Camera is located on the MLP deck and views the
400 FPS RH SRB southwest holddown post (HDP #1).
16mm

Focus :
F. O. V.:
Exposure:

Comments: A FEW IGNITER SPARKS FROM ROFI'S LAND ON MLP DECK.
SMALL PIECES OF FACILITY DEBRIS AND INSTAFOAM TRIMMINGS ARE
KICKED UP OUT OF THE HOLDDOWN POST HAUNCH AREA BY SSME IGNITION
AND SOME ARE PULLED TOWARD THE MAIN ENGINES BY ASPIRATION. NO
FRAGMENTS DROP FROM AFT SKIRT STUD HOLE AND NO PIECES OF
INSTAFOAM BREAK AWAY FROM AFT SKIRT CLOSEOUT. ALL SRB THERMAL
CURTAIN TAPE IS INTACT. SMALL PIECES OF SRB THROAT PLUG MATERIAL
ENTER FOV AS VEHICLE RISES.

E-10 Camera is located on the MLP deck and views the
400 FPS RH SRB northwest holddown post (HDP #3).
16mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: MLP DECK SCALE AND INSTAFOAM TRIMMINGS ARE DRAWN
ACROSS MLP DECK BY SSME ASPIRATION. MANY PARTICLES OF SRB THROAT
PLUG MATERIAL ARE KICKED UP OUT OF THE FLAME HOLE AFTER T-0.
HOLDDOWN POST DOGHOUSE BLAST COVER BEGINS TO CLOSE NORMALLY AND

THEN IS OBSCURED BY SMOKE. NO FRANGIBLE NUT OR NSI FRAGMENTS FALL FROM AFT SKIRT STUD HOLE. SRB THERMAL CURTAIN TAPE IS INTACT WHILE IN VIEW.

E-11 Camera is located on the MLP deck and views the
400 FPS LH SRB northeast holddown post (HDP #7).
16mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: MLP DECK SCALE IS DRAWN ACROSS MLP DECK BY SSME IGNITION. RYMPLE CLOTH APPEARS FROM BEHIND HDP #7 AFTER T-0. HOLDDOWN POST DOGHOUSE BLAST COVER CLOSES NORMALLY. PARTICLES OF SRB THROAT PLUG MATERIAL ARE KICKED UP OUT OF FLAME HOLE AFTER SRB IGNITION. THERMAL CURTAIN TAPE IS INTACT WHILE IN VIEW. DARK PARTICLE ENTERING TOP OF FRAME AND FALLING PAST AFT SKIRT STUD HOLE IS NOT FRANGIBLE NUT/NSI FRAGMENT. BACKWASH OF PLUME FLAME AND SMOKE RISES ALONG SIDE OF NOZZLE EXTENSION AND IMPACTS AFT SKIRT FOOT/INSTAFOAM AREA.

E-12 Camera is located on the MLP deck and views the
400 FPS LH SRB southeast holddown post (HDP #5).
16mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: ONE HALF-INCH PIECE OF K5NA BREAKS LOOSE FROM BSM CLOSEOUT AND LANDS ON HOLDDOWN POST DEBRIS PLUNGER HOUSING. SMALL PIECES OF FACILITY DEBRIS ENTER FOV AFTER SSME IGNITION. HARD ICE AND FROST PARTICLES FROM ET/ORB LH2 UMBILICAL FALL INTO VIEW AND LAND ON MLP DECK. ONE LARGE FRANGIBLE NUT FRAGMENT DROPS FROM AFT SKIRT STUD HOLE JUST AS VEHICLE STARTS TO RISE. AFTER THE VEHICLE RISES 3 FEET, TWO PIECES OF NSI ALSO DROP FROM THE STUD HOLE. NO INSTAFOAM OR THERMAL CURTAIN TAPE ANOMALIES.

E-13 Camera is located on the MLP deck and views the
400 FPS LH SRB southwest holddown post (HDP #6).
16mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: VIEW IS PARTIALLY OBSCURED BY WATER DELUGE. SEVERAL ROFI SPARKS FALL INTO FLAME HOLE. SSME IGNITION OCCURS AT FRAME 2289 FOLLOWED BY T-0 AT FRAME 4215. AT FRAME 2435, DEBRIS APPEARS OUT OF A CRACK IN THE MLP DECK. ICE PARTICLES TRAVEL FROM TOP RIGHT TO LOWER LEFT CLOSE IN TO CAMERA (FRAME 4184). A 3"X2" PIECE OF DEBRIS ORIGINATES FROM AN AREA BEHIND THE WATER PIPE AND IMPACTS THE SRB AFT SKIRT NEAR THE HOLDDOWN POST (FRAME 4532). FIVE PARTICLES OF ICE FALL DURING ASCENT. THREE PIECES OF DEBRIS FALL BETWEEN THE BSM AND THE HOLDDOWN POST.

E-14 Camera is located on the MLP deck and views the
400 FPS LH SRB northwest holddown post (HDP #8).
16mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: AT SSME IGNITION, FACILITY DEBRIS IS DRAWN ACROSS THE MLP DECK BY ASPIRATION. T-0 OCCURS AT FRAME 4252. HOLDDOWN POST DOGHOUSE BLAST COVER CLOSURE APPEARS TO BE SLOW, BUT FINAL CLOSURE IS OBSCURED BY SMOKE. FOIL TYPE DEBRIS FALLS DURING VEHICLE ASCENT.

E-15 Camera is located on the MLP deck and views the RH
400 FPS SRB skirt, sound suppression water troughs, and RH
16mm lower Orbiter body flap.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: ICE AND FROST PARTICLES FALL FROM ET/ORB LO2 UMBILICAL AS SSME'S IGNITE. A PIECE OF TILE APPEARS FROM BEHIND BODY FLAP (FRAME 3330) NEAR SSME #3. HOLDDOWN POST DOGHOUSE BLAST COVERS CLOSE BEFORE NOZZLE EXTENSION PASSES. NO INSTAFOAM OR THERMAL CURTAIN TAPE ANOMALIES. SRB THROAT PLUG MATERIAL ENTERS FOV AS VEHICLE RISES. SMALL PIECES OF FACILITY DEBRIS ARE VISIBLE AFTER VEHICLE CLEARS FRAME.

E-16 Camera is located on the MLP deck and views the LH
400 FPS SRB skirt, sound suppression water troughs, and LH
16mm lower Orbiter body flap.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: ICE FALLS FROM SSME LOX OVERBOARD VENT LINE AS SSME'S IGNITE. HYDROGEN FLAME IS BLOWN WEST BY WIND AROUND AFT RCS STINGER AND BODY FLAP. LARGE QUANTITY OF ICE/FROST PARTICLES ARE SHAKEN LOOSE FROM ET/ORB LH2 UMBILICAL WHEN SSME'S START, BUT NO DAMAGE TO ORBITER TILES IS VISIBLE. RYMPLE CLOTH IS PULLED FROM HOLDDOWN POST #7 WHEN SRB'S IGNITE. RECIRCULATION FLAME FROM SRB PLUME RISES ALONG NOZZLE EXTENSION NEAR HOLDDOWN POST #7. HDP DOGHOUSE BLAST COVERS ARE NOT CLOSED COMPLETELY AS SRB NOZZLE EXTENSIONS PASS BY. NO FRAGMENTS DROP FROM AFT SKIRT STUD HOLES AND SHIMS ARE INTACT. NO ANOMALIES WITH SRB INSTAFOAM CLOSEOUT OR THERMAL CURTAIN TAPE.

E-17 Camera is located on the MLP deck and views the
400 FPS -Z side of the LO2 T-0 Umbilical and TSM.
16mm

Comments: FILM BROKE AT CAMERA START.

E-18 Camera is located on the MLP deck and views the
400 FPS -Z side of the LH2 T-0 umbilical and TSM.
16mm

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED

Comments: FREE HYDROGEN IGNITES, IS BLOWN WEST, AND RISES ALONG SIDE OF SSME #2/LH2 TSM. RCS PAPER COVERS RUPTURE AND A TILE ON THE ORBITER BASE HEAT SHIELD ADJACENT TO THE ENGINE MOUNTED HEAT SHIELD CHIPS BEFORE SSME #2 PLUME STABILIZES. WATER DELUGE SPRAY FROM THE FSS IS DRAWN TOWARD THE MAIN ENGINES BY ASPIRATION. ICE AND FROST PARTICLES ARE SHAKEN LOOSE FROM THE ET/ORB LH2 UMBILICAL. THE WIND BLOWS MANY OF THE PARTICLES WESTWARD, BUT NO TILE CONTACT OR DAMAGE IS VISIBLE. SEPARATION OF THE LH2 T-0 UMBILICAL IS NOMINAL AND PIECES OF ICE FALL CLEAR OF THE VEHICLE.

E-19 Camera is located on the SE side of the MLP deck
400 FPS and views the SSME/OMS nozzles and Orbiter aft
16mm heat shield area.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: FREE HYDROGEN BURNS AND IS BLOWN WESTWARD. RCS PAPER
COVERS RUPTURE AT SSME START. AFT FACING TILE ON RH RCS STINGER
IS CHIPPED BY SSME IGNITION (FRAME 2462). TWO PIECES OF TILE
COATING MATERIAL ARE MISSING AT THE 11 O'CLOCK POSITION OF SSME
#3 (FRAME 2525) DURING STARTUP. HAT BAND #7 THERMAL INSULATION
BLANKET IS LOOSE ON SSME #1 (FRAME 2657). SSME IGNITION IS
NOMINAL. BASE HEAT SHIELD TILE AT SSME #3 ENGINE MOUNTED HEAT
SHIELD 3 O'CLOCK POSITION CHIPS AT FRAME 3109. A 6"X3"X1" TILE
PIECE BREAKS FROM THE BODY FLAP HINGE AREA AND IS VISIBLE UNDER
THE BODY FLAP AT FRAME 3407. LO2 T-0 UMBILICAL SEPARATION IS
NORMAL, THOUGH ICE AND RESIDUAL VAPORS FALL DURING RETRACTION.
LH2 TSM DOOR BOUNCES UP ABOUT 5 INCHES BEFORE CLOSING. RTV CORD
IS ATTACHED TO RCS PAPER COVER CLOSEOUT ON RH RCS STINGER AND
WHIPS AROUND DURING THE FIRST 100 FEET OF ASCENT.

E-20 Camera is located on the SW side of the MLP deck
400 FPS and views the SSME/OMS nozzles and Orbiter aft
16mm heat shield area.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: FREE HYDROGEN BURNS AND IS BLOWN WESTWARD. RCS PAPER
COVERS RUPTURE AT SSME START. PIECES OF THE RCS COVERS FALL
CONTINUOUSLY UNTIL THE FORMATION OF SHOCK DIAMONDS. THE TILE
PIECE FROM THE BODY FLAP HINGE AREA APPEARS FROM BEHIND SSME #3
(FRAME 3236) AND FALLS AFT. SSME IGNITION IS NOMINAL. LH2 T-0
SEPARATION IS NORMAL, THOUGH ICE DROPS FROM THE PURGE BOX.
ORBITER BASE HEAT SHIELD HAS FEW TILE DINGS.

E-21 Camera is located inside the LO2 TSM and views
200 FPS the disconnection of the T-0 umbilical.
16mm

Focus : SLIGHTLY SOFT
F. O. V.: OK
Exposure: OK

Comments: T-0 OCCURS AT FRAME 2284. LO2 T-0 CARRIER PLATE DISCONNECT AND RETRACTION APPEAR NOMINAL.

E-22 Camera is located inside the LH2 TSM and views
200 FPS the disconnection of the T-0 umbilical.
16mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: PURGE BARRIER SEPARATES FROM TSM DOOR AND LAYS ACROSS INTERFACE PLATE. T-0 OCCURS AT 2290. LH2 T-0 CARRIER PLATE DISCONNECT AND RETRACTION APPEAR NOMINAL.

E-23 Camera is located on the MLP deck and views the
400 FPS RH OMS engine nozzle.
16mm

Focus : SOFT
F. O. V.: OK
Exposure: OK

Comments: SSME IGNITION OCCURS AT FRAME 2357. RCS PAPER COVERS TEAR SOON AFTER ENGINE STARTUP. A TILE IS CHIPPED AT THE 9 O'CLOCK POSITION ON THE OMS EYEBALL (FRAME 2483) FOLLOWED BY ANOTHER TILE CHIP AT THE 11 O'CLOCK POSITION. T-0 OCCURS AT FRAME 4364. PIECES OF ICE FALL FROM THE ORBITER T-0 UMBILICAL DURING NOMINAL RETRACTION/LO2 TSM DOOR CLOSURE. THE LARGE VAPOR CLOUD BEHIND THE NOZZLE ORIGINATES FROM THE T-0 UMBILICAL AFTER DISCONNECT. AS THE VEHICLE ASCENDS, TWO CHIPPED TILES ARE VISIBLE ON THE AFT INBOARD SIDE OF THE RCS STINGER.

E-24 Camera is located on the MLP deck and views the
400 FPS LH OMS engine nozzle.
16mm

Focus : SLIGHTLY SOFT
F. O. V.: SLIGHTLY HIGH
Exposure: OK

Comments: SMOKE IS CAUSED BY ROFI'S. FREE HYDROGEN HAS BEEN IGNITED AND IS BLOWN TOWARD LH2 TSM BY WIND. IGNITER SPARKS HIT HEAT SHIELD AREA AND OMS NOZZLE. SSME IGNITION OCCURS AT FRAME 2359 AND RCS PAPER COVERS RIP SOON AFTER. T-0 OCCURS AT FRAME 4355. ALTHOUGH MUCH ICE FALLS FROM THE LH2 T-0 UMBILICAL, RETRAC-

TION IS NORMAL. ICE ALSO FALLS FROM THE ET/ORB UMBILICAL. AS THE VEHICLE ASCENDS, 9 TILE DINGS ON THE BASE HEAT SHIELD AND 4 TILE DINGS ON THE RCS STINGER ARE VISIBLE.

E-25 Camera is located on the east side of the MLP and
400 FPS views between Orbiter and ET/SRB during liftoff.
16mm

Focus : OK
F. O. V.: SHIFTED TOO FAR RIGHT
Exposure: SLIGHTLY UNDEREXPOSED

Comments: FACILITY WATER DELUGE SPRAY IS VISIBLE BEHIND ET/ORB UMBILICALS. A CORD OF RTV IS ATTACHED TO THE RCS PAPER COVER CLOSEOUT ON THE RCS STINGER. RCS PAPER COVERS FALL AFT AND THE RH WING ELEVONS FLEX AS THE VEHICLE ASCENDS. ICE PARTICLES AND RESIDUAL VAPORS FALL FROM LO2 T-0 UMBILICAL. NO VAPORS ARE VISIBLE IN THE VICINITY OF THE ET/ORB LH2 UMBILICAL. ET AND SRB'S LOOK NOMINAL.

E-26 Camera is located on the west side of the MLP and
400 FPS views between Orbiter and ET/SRB during liftoff.
16mm

Focus : OK
F. O. V.: SHIFTED TOO FAR LEFT
Exposure: SLIGHTLY UNDEREXPOSED

Comments: SMOKE FROM ROFI'S DRIFTS WEST. WATER DELUGE SPRAYS ORIGINATES FROM ET INTERTANK ACCESS ARM. ICE PARTICLES FALL FROM ET/ORB UMBILICALS AND IS BLOWN WEST TOWARDS CAMERA.

E-27 Camera is located on the MLP deck and views RH SRB
400 FPS northwest holddown post (HDP #3) blast cover.
16mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: A FLAKE OF MATERIAL APPEARS FROM UNDER WATER DELUGE HEADER BEHIND HOLDDOWN POST #4 AND FALLS INTO FLAME HOLE (FRAME 325). SSME IGNITION OCCURS AT FRAME 2556 AND CAUSES ICE TO FALL FROM ET/ORB LH2 UMBILICAL. A SMALL PIECE OF TAPE COMES OFF BAGGIE

CORD. T-0 OCCURS AT FRAME 4564 AND SMALL PIECES OF SRB THROAT PLUG MATERIAL ARE KICKED UP OUT OF FLAME HOLE. HOLDDOWN POST DOGHOUSE BLAST COVER APPEARS TO CLOSE NORMALLY.

E-28 Camera is located on the MLP deck and views LH SRB
400 FPS northeast holddown post (HDP #7) blast cover.
16mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: SSME IGNITION OCCURS AT FRAME 2238 FOLLOWED BY T-0 AT FRAME 4293. THROAT PLUG MATERIAL IS EJECTED OUT OF FLAME HOLE. RYMPLE CLOTH APPEARS FROM BEHIND HDP #7. HOLDDOWN POST DOGHOUSE BLAST COVER CLOSURE IS OBSCURED.

E-30 Camera is located on the FSS 195 foot level and
400 FPS views LH SRB and sound suppression water troughs.
16mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: SSME IGNITION OCCURS AT FRAME 1723 FOLLOWED BY T-0 AT FRAME 3869. UNIDENTIFIED OBJECT, POSSIBLY ICE, FROM UNKNOWN SOURCE FALLS NEAR ORBITER LH WING AT FRAME 3433. SEVERAL PIECES OF ICE FALL FROM ET/ORB LH2 UMBILICAL.

E-31 Camera is located on the FSS 95 foot level and
100 FPS views the LH Orbiter wing, body flap, and
16mm ET/Orbiter LH2 umbilical area.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: WHITE SMOKE FROM ROFI'S IS BLOWN TOWARD FSS. SSME IGNITION SEQUENCE BEGINS AT FRAME 617. SSME START UP CAUSES ICE TO BREAK AWAY AND FALL FROM ET/ORB LH2 UMBILICAL. ICE ALSO FALLS FROM ET SIDE OF LH2 RECIRCULATION LINE BELLWS AND LO2 FEEDLINE AREA. NONE OF THIS ICE CAUSES ANY DAMAGE TO ORBITER TILES. ICE FALLING FROM ET/ORB LO2 UMBILICAL STRIKES TOP SURFACE OF CABLE TRAY. ELEVONS VIBRATE DURING SSME STARTUP. AT FRAME 984, A WHITE OBJECT ENTERS TOP OF FRAME AND FALLS VERTICALLY WITHOUT CONTACT-

ING THE ORBITER. T-0 OCCURS AT FRAME 1107. AS VEHICLE LIFTS OFF, MORE ICE AND FROST PARTICLES FALL FROM ET/ORB UMBILICALS, BUT NO TILE DAMAGE IS VISIBLE. NO UNUSUAL VAPORS EMANATE FROM ET/ORB UMBILICAL AREA. NO SRB ANOMALIES.

E-33 Camera is located on the FSS 235 foot level and
400 FPS views the ET GH2 vent line and GUCP.
16mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: SSME IGNITION SEQUENCE, BEGINNING AT FRAME 1760, INITIATES A SHOWER OF ICE/FROST PARTICLES FROM THE GUCP LEG AND CARRIER PLATE. T-0 OCCURS AT FRAME 3610. MORE ICE/FROST FALLS AS THE GUCP SEPARATES FROM THE ET. RETRACTION IS NOMINAL AND THE GUCP DOES NOT CONTACT THE VEHICLE. FROST IS STILL PRESENT ALONG THE LOWER PERIMETER OF THE ET CARRIER PLATE AND SOME VAPORS WERE STILL EXITING THE 7-INCH QD. NO TPS WAS PULLED OFF BY GUCP DISCONNECT. RUSTY STREAKS ON THE LH SRB CASE WERE CAUSED BY WATER FROM THE DELUGE SYSTEM SPRAY.

E-34 Camera is located on FSS at 255 foot level and
400 FPS views upper Orbiter tile surfaces.
16mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: A THIN 4"X3" PIECE OF LIGHT-COLORED MATERIAL, POSSIBLY TPS TRIMMING, APPEARS FROM THE ET INTERTANK AREA STARTING AT FRAME 2820, FLOATS DOWN PAST THE BIPODS, AND CONTACTS THE ORBITER TWICE ON THE LH FORWARD LOWER SURFACE (FRAMES 5372 AND 5951). NO APPARENT TILE DAMAGE RESULTS. FOUR ICE PARTICLES APPEAR FROM THE SAME AREA ABOVE THE BIPODS, BUT DO NOT IMPACT THE ORBITER (FRAME 6264). SEVERAL ICE PARTICLES FALL BELOW THE UMBILICAL AREA, BUT DO NOT CONTACT THE ORBITER (FRAME 7109). STREAKS ON THE LH SRB ARE CAUSED BY RUSTY WATER FROM THE DELUGE SYSTEM. AERODYNAMICS CAUSE PAPER COVERS ON LH FWD RCS TO FLAP.

E-35 Camera is located on the FSS 255 foot level and
400 FPS views the mid-Orbiter/ET/SRB area.
16mm

Focus : GOOD
F. O. V.: GOOD
Exposure: SLIGHTLY UNDEREXPOSED

Comments: SSME IGNITION SEQUENCE IS INITIATED AT FRAME 1281. EIGHT PIECES OF ICE FROM THE ET LO2 FEEDLINE FORWARD BELLOWS AREA FELL ALONG THE LOWER LEFT SURFACE OF THE ORBITER (FROM THE RIGHT SIDE), BUT DID NOT APPEAR TO CONTACT THE ORBITER (FRAME 2087). A LIGHT PIECE OF DEBRIS FLOATS IN FIELD OF VIEW FOR SEVERAL SECONDS. IT IS FOLLOWED BY ONE FASTER MOVING PARTICLE AND SEVERAL SMALLER PARTICLES THAT DO NOT CONTACT THE ORBITER. GUCP DISCONNECT AND RETRACTION IS NOMINAL. SEVERAL PIECES OF ICE FALL FROM THE GUCP AFTER SEPARATION FROM THE ET. WATER FROM SRB STIFFENER RINGS VAPORIZES. AFTER THE VEHICLE CLEARS THE TOWER, AN AIRBORNE METAL HINGE 5"X2" IN SIZE APPEARS TO HAVE ORIGINATED FROM THE FACILITY (FRAME 6262).

E-36 Camera is located on the FSS 255 foot level and
400 FPS views lower Orbiter, ET, SRB's, and water trough.
16mm

Focus : GOOD
F. O. V.: GOOD
Exposure: GOOD

Comments: SSME IGNITION SEQUENCE INITIATED AT FRAME 1019. THREE PARTICLES (REF E-35) DO NOT APPEAR TO CONTACT THE ORBITER (FRAME 2157). T-0 OCCURS AT FRAME 3004. RCS PAPER COVERS ARE DRAWN BEHIND LH STINGER (FRAME 3925). METAL FACILITY HINGE (REF E-35) APPEARS IN FOV AT FRAME 6167.

E-39 Camera is located on the FSS 185 foot level and
400 FPS views GH2 vent line latchback.
16mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: WATER DELUGE DROPLETS PARTIALLY OBSCURE VIEW. GH2 VENT LINE RETRACT AND LATCHBACK ARE NOMINAL. LINE DOES NOT REBOUND.

E-40 Camera is located on the FSS 275 foot level and
400 FPS views the ET ogive, SRB nosecone, and Orbiter
16mm tiled surfaces.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: STREAKS ON LH SRB ARE CAUSED BY RUSTY DELUGE WATER. LH FWD RCS PAPER COVERS FLAP AT FRAME 4990. SEVERAL PIECES OF UMBILICAL ICE FALL PAST BODY FLAP (FRAME 5783) WITH NO APPARENT TILE DAMAGE. TORN PIECES OF AFT RCS PAPER COVERS ARE DRAWN BEHIND SSME'S (FRAME 5912).

E-41 Camera is located on the FSS 255 foot level and
400 FPS views the GH2 vent line during rotation. Also
16mm shows clearance between structure and SRB aft skirt.

Focus : OK
F. O. V.: OK
Exposure: SLIGHTLY UNDEREXPOSED

Comments: WATER SPRAYS FROM ET INTERTANK ACCESS ARM STRUCTURE. SSME IGNITION SEQUENCE BEGINS AT FRAME 1603. THREE LIGHT COLORED PARTICLES FALL VERTICALLY DOWN FROM ET INTERTANK AREA IN BETWEEN ET AND ORBITER (FRAME 1692). T-0 OCCURS AT FRAME 2620. ONE LIGHT COLORED OBJECTS FLOATS INTO VIEW JUST BELOW ET INTERTANK AREA (FRAME 2705) AND DRIFTS TOWARD ORBITER OUT OF FOV. GH2 VENT ARM RETRACTION AND LATCHBACK ARE NOMINAL - NO VEHICLE CONTACT OR REBOUND. AT FRAME 3699, A WHITE FLAKE PASSES NEAR CAMERA HEADING UPWARD. NO ET OR SRB ANOMALIES. STREAKS ON LH SRB CASE ARE CAUSED BY WATER DELUGE SPRAY. TYPICAL FACILITY DEBRIS PASSES THROUGH FOV WELL AFTER VEHICLE CLEARS TOWER.

E-42 Camera is located on the FSS 185 foot level and
400 FPS views the GH2 vent line drop, deceleration, and
16mm latchback.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: GH2 VENT LINE RETRACTION AND LATCHBACK IS NOMINAL. RESTRAINT CABLE IS REELED IN AND DOES NOT DANGLE. SEVERAL DEBRIS PARTICLES ENTER FOV: A THIN, DARK OBJECT MOVING DOWN AND TOWARD FSS (FRAME 3279), A WHITE OBJECT APPEARING FROM EAST AND THEN FALLING STRAIGHT DOWN (FRAME 3376), DARK OBJECTS CLOSE IN TO ET INTERTANK ACCESS ARM STRUCTURE FALLING STRAIGHT DOWN (FRAMES

3529, 3800, 4079), AND ONE MORE DARK OBJECT NEAR THE HAUNCH (FRAME 4116). TYPICAL FACILITY DEBRIS ENTERS FOV AFTER VEHICLE CLEARS TOWER.

E-43 Camera is located on pad surface and views sound
200 FPS suppression water flow distribution beneath MLP.
16mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: HYDROGEN FLAME BENEATH MLP AT SSME START IS QUICKLY OBSCURED BY STEAM AND WATER DELUGE. NO UNUSUAL FACILITY DEBRIS IS VISIBLE.

E-44 Camera is located on the FSS 155 foot level and
400 FPS views the LH OMS Pod leading edge tiles during
16mm ignition and liftoff.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: T-0 OCCURS AT FRAME 4068 AND RESIDUAL VAPORS EMANATE FROM THE LH2 T-0 UMBILICAL QUICK DISCONNECTS. AT FRAME 3872, A SMALL WHITE PARTICLE ENTER TOP OF FRAME AND FALLS DOWNWARD WEST OF LH2 TSM. A +Z RCS PAPER COVER APPEARS FROM BENEATH THE BASE HEAT SHIELD (FRAME 4411). NO TPS ANOMALIES ARE VISIBLE ON THE LH OMS POD.

E-48 Camera is located on the FSS 215 foot level (ET
400 FPS Intertank access arm structure) and views the GH2
16mm vent line during GUCP disconnection, rotation, and
latchback

Focus : SLIGHTLY SOFT
F. O. V.: OK
Exposure: OK

Comments: SSME IGNITION CAUSES ICE AND FROST PARTICLES TO FALL FROM GUCP LEG. T-0 OCCURS AT FRAME 2900. GH2 VENT LINE DISCONNECT AND RETRACT IS NOMINAL. LINE DOES NOT CONTACT VEHICLE. ICE AND FROST PARTICLES FALL FROM GUCP AND ET PLATES AT DISCONNECT. ICE

PARTICLES CONTINUE TO FALL FROM ET/ORB LH2 UMBILICAL AS VEHICLE RISES - NO VISIBLE DAMAGE TO TILES. STREAKS ON LH SRB ARE CAUSED BY FACILITY WATER DELUGE SPRAY.

E-50 Camera is located at camera site 1 at NE pad
400 FPS perimeter and views entire GH2 vent line and
16mm GUCP during rotation and latchback.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: WATER FROM ET INTERTANK ACCESS ARM STRUCTURE IS BLOWN SOUTHWARD. T-0 OCCURS AT FRAME 3696. GH2 VENT LINE RETRACTION AND LATCHBACK IS NOMINAL. NO VEHICLE ANOMALIES.

E-52 Camera is located at camera site 2 on the east pad
96 FPS perimeter. Remote tracking of lower one-third of
35mm launch vehicle from ignition to 1200 feet.

Focus : OK
F. O. V.: OK
Exposure: SLIGHTLY UNDEREXPOSED

Comments: RUSTY DELUGE WATER IS SPRAYED ON MLP SOUTH SIDE LH2 SKID. SSME IGNITION IS NOMINAL. WATER FROM SRB STIFFENER RINGS AND CONDENSATE FROM ET AFT DOME VAPORIZES WHILE AFT SKIRT INSTAFOAM OUTGASSES DURING EARLY ASCENT. ET AFT DOME CHARRING HAS BEGUN PRIOR TO THE ROLL MANEUVER. RCS PAPER COVERS AND PARTICLES OF ICE CONTINUE TO FALL THROUGH THE ROLL PROGRAM. BOTH ET/ORB UMBILICALS LOOK NOMINAL WITH NO UNUSUAL VAPORS.

E-53 Camera is located at camera site 2 on the east pad
96 FPS perimeter. Remote tracking of middle one-third of
35mm launch vehicle from ignition to 1200 feet.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: CONDENSATE FROM ET AFT DOME AND SRB STIFFENER RINGS VAPORIZES. LH2 AFT DOME BEGINS TO CHAR BY ROLL MANEUVER. RCS PAPER COVERS FALL FROM BOTH AFT RCS STINGERS. DEBRIS, PROBABLY ICE, FALLS FROM LO2 T-0 UMBILICAL PLATE AT FRAME 1293. TWO PIECES

OF RCS PAPER COVERS FALL OVER TOP SIDE OF LH WING (FRAME 1863) AND MOST LIKELY ORIGINATED FROM THE LH FWD RCS. A FLASH APPEARS IN THE SSME PLUME (FRAME 3241).

E-54 Camera is located at camera site 2 on the east pad
100 FPS perimeter. Remote tracking of upper one-third of
35mm launch vehicle from ignition to 1200 feet.

Comments: FILM DID NOT RUN.

E-57 Camera is located at camera site 6 on the NW pad
96 FPS perimeter. Remote tracking of lower one-third of
35mm launch vehicle from ignition to 1200 feet.

Focus : OK
F. O. V.: OK, BUT LOST TRACKING 4 TIMES
Exposure: OK

Comments: WATER DELUGE SPRAYS FROM THE ET INTERTANK ACCESS STRUCTURE. ICE FALLS FROM THE FSS CRYOGENIC LINES. DURING SSME IGNITION, ONE BIRD FLIES OUTBOUND AWAY FROM THE VEHICLE AND A SECOND BIRD IS ALSO OUTBOUND AS THE VEHICLE RISES - NO STRIKES. NO SLIDEWIRE BASKETS ARE RELEASED FROM SSME STARTUP THROUGH TOWER CLEAR. PARTICLES OF ICE FROM THE UMBILICALS AND PIECES OF RCS PAPER COVERS FALL DURING EARLY ASCENT. WATER FROM THE SRB STIFFENER RINGS AND CONDENSATE FROM THE ET AFT DOME VAPORIZES. AFT SKIRT INSTAFOAM OUTGASSES SHORTLY AFTER LIFTOFF. THE ET AFT DOME HAS BEGUN TO CHAR PRIOR TO THE ROLL MANEUVER. GOOD VIEW OF THE VEHICLE TPS THROUGH THE ROLL PROGRAM, BUT NO ANOMALIES ARE VISIBLE.

E-58 Camera is located at camera site 6 on the NW pad
96 FPS perimeter. Remote tracking of center one-third of
35mm launch vehicle from ignition to 1200 feet.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: SEE COMMENTS FOR E-57.

E-59 Camera is located at camera site 6 on the NW pad
100 FPS perimeter. Remote tracking of upper one-third of
35mm launch vehicle from ignition to 1200 feet.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: RUSTY/DARK STREAKS ON LH SRB ARE CAUSED BY WATER DELUGE SYSTEM. T-0 BY ALPHANUMERIC TIMING IS 18:46:59.1. NO UNUSUAL VAPORS OR OUTGASSING FROM ET/ORB UMBILICALS. CONDENSATE VAPORIZES ON ET AFT DOME DURING ASCENT. VAPORS EMANATE FROM THE ET GH2 8-INCH VENT LINE FROM T-0 THROUGH 18:47:09. SIXTEEN PIECES OF ICE OR RCS PAPER COVERS FALL AFT OF VEHICLE DURING TIME FRAME 18:47:05 - 18:47:08. APPROXIMATELY 20 PIECES ARE VISIBLE ON THE RH SIDE (18:47:11.40). SEVENTEEN PIECES OF INSTAFOAM, POSSIBLY FROM THE RH SRB AFT SKIRT, FALL ALONG THE -Z SIDE OF THE VEHICLE DURING ASCENT 18:47:25. ORBITER FWD RCS PAPER COVERS REMAIN INTACT.

E-60 Camera is located on north pad perimeter at camera
96 FPS site 1 and views the entire launch vehicle, FSS,
35mm and MLP zero level.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: RUSTY WATER IS SPRAYED FROM THE FACILITY HYDROGEN HAUNCH AREA. T-0 OCCURS AT FRAME 852. CONDENSATE FROM THE ET AFT DOME AND SRB STIFFENER RINGS VAPORIZES. THREE PIECES OF ICE FALL FROM THE ET/ORB LH2 UMBILICAL. FOUR PIECES OF RCS PAPER COVER ARE LOST FROM THE RH STINGER.

E-61 Camera is located at camera site 2 on the east pad
100 FPS perimeter and views the launch vehicle, FSS, and
35mm MLP.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: DARK WATER IS SPRAYED ON THE MLP SOUTH SIDE LO2 SKID. RH SRB HPU EXHAUST IS VISIBLE INTERMITTENTLY. ICE FALLS FROM THE GH2 FACILITY VENT LINE DURING RETRACTION. T-0 OCCURS AT 18:46:59.3.

E-62 Camera is located on the SE pad perimeter at
96 FPS camera site 3 and views entire vehicle, FSS, and
35mm MLP.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: DARK WATER IS SPRAYED ON THE MLP SOUTH SIDE LO2 SKID AND ON THE FACILITY HYDROGEN HAUNCH AREA. SSME IGNITION OCCURS AT FRAME 411 FOLLOWED BY T-0 AT FRAME 875. WATER FROM SRB STIFFENER RINGS VAPORIZES. RCS PAPER COVERS FALL FROM RH STINGER AT FRAME 1083.

E-63 Camera is located on SW pad perimeter at camera
96 FPS site 4 and views entire launch vehicle, FSS, and
35mm MLP.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: DARK WATER IS SPRAYED ON MLP SOUTH SIDE LO2 SKID. SSME PLUME OBSCURES FOV BY FRAME 1163. NO SLIDE WIRE BASKETS HAVE RELEASED TO THIS POINT. NO VEHICLE ANOMALIES WERE NOTED.

E-64 Camera is located on NW pad perimeter at camera
96 FPS site 6 and views entire launch vehicle, FSS, and
35mm MLP.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: T-0 OCCURS AT FRAME 820. ICE FALLS FROM MLP NORTH AND WEST CROSS COUNTRY CRYO LINES. FOV OBSCURED BY HAZE. WATER FROM LH AND RH SRB STIFFENER RINGS VAPORIZES. SLIDE WIRE BASKETS HAVE NOT RELEASED THROUGH FRAME 1463.

E-65 Camera is located on east pad perimeter at camera
100 FPS site 2 and views ET LO2 feedline, ET intertank,
16mm and RH SRB as vehicle passes through the frame.

Focus : SLIGHTLY SOFT
F. O. V.: OK
Exposure: UNDEREXPOSED

Comments: SEVERAL PARTICLES OF ICE FALL FROM THE ET/ORB UMBILICALS, BUT NO IMPACTS OR DAMAGE TO TILES IS VISIBLE. ICE REMAINS IN LO2 FEEDLINE BELLOW. ET/ORB UMBILICALS ARE CLEAR OF VAPORS. NO VEHICLE ANOMALIES.

E-76 Camera is located on SE pad perimeter at camera
96 FPS site 3 and views SSME engines #1 and #3 and the RH
35mm OMS engine nozzle.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: RUSTY WATER IS SPRAYED ON MLP SOUTH SIDE LH2 SKID. ROFI ON LH2 TSM SOUTH SIDE FLARES MOMENTARILY FROM POCKET OF FREE HYDROGEN (FRAME 251). SSME #3 STARTUP SEQUENCE BEGINS AT FRAME 259. ORBITER VERTICAL STABILIZER VIBRATES SIDE TO SIDE DURING SSME IGNITION, BUT MOVEMENT DAMPENS PRIOR TO T-0. THE THERMAL INSULATION BLANKET ON SSME #1 HATBAND #7 IS LOOSE. MISSING TILE PIECE FROM ORBITER BODY FLAP HINGE AREA FALLS PAST SSME #3 NOZZLE AT FRAME 480. ICE AND FROST PARTICLES FALL FROM ORBITER LO2 T-0 UMBILICAL, BUT DISCONNECT IS NOMINAL. ICE PARTICLES FALL FROM BOTH ET/ORB UMBILICALS DURING EARLY ASCENT. PAPER COVERS SEPARATE FROM LH RCS STINGER AS VEHICLE RISES. NO SRB ANOMALIES. PIECES OF WATER TROUGH MATERIAL ENTER FOV AFTER VEHICLE CLEARS TOWER.

E-77 Camera is located on SW pad perimeter at camera
96 FPS site 4 and views SSME engines #1 and #2 and the LH
35mm OMS engine nozzle.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: ROFI ON LH2 TSM SOUTH SIDE FLARES MOMENTARILY FROM POCKET OF FREE HYDROGEN. SSME IGNITION IS NOMINAL. RCS PAPER COVERS RUPTURE AT START OF SSME IGNITION. PARTICLES OF ICE/FROST FROM ORBITER T-0 UMBILICALS AND SSME HEATSHIELD INTERFACES CONTINUE TO FALL DURING SSME STARTUP. PIECES OF RCS PAPER COVER FROM THE INBOARD SIDE OF THE LH RCS STINGER PASS BEHIND OMS ENGINE AND ARE DRAWN INTO SSME PLUME. THE TILE PIECE FROM THE BODY FLAP HINGE AREA APPEARS BEHIND SSME #2 NOZZLE AT FRAME 443. LH2 T-0 UMBILICAL DISCONNECT AND RETRACTION IS NORMAL. NO SRB ANOMALIES.

E-78 Camera is located on SE pad perimeter at camera
400 FPS site 3 and views RH OMS Pod leading edge.
16mm

Comments: DID NOT RUN.

E-79 Camera is located on east pad perimeter at
100 FPS camera site 2 and views the ET nosecone, louver,
16mm and ogive.

Focus : VERY SOFT
F. O. V.: OK
Exposure: SLIGHTLY UNDEREXPOSED

Comments: ESTIMATED VEHICLE 'TWANG' IS 32-33 INCHES. T-0 OCCURS
AT FRAME 1064. NO ICE IS VISIBLE IN THE LOUVER. NO VEHICLE
ANOMALIES AND THE ET/ORB UMBILICALS ARE CLEAR OF VAPORS.

E-201 UCS-9 IFLOT tracking of launch vehicle from
30 FPS ignition and early flight through LOV.
70mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: SAME AS E-223.

E-202 UCS-15 IFLOT tracking of launch vehicle from
30 FPS ignition and early flight through LOV.
70mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: SAME AS E-222.

E-203 UCS-6 IFLOT tracking of launch vehicle from
30 FPS ignition and early flight through LOV.
70mm

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED

Comments: NUMEROUS DEBRIS PARTICLES APPEAR BETWEEN THE SRB'S DURING ASCENT. THE PARTICLE SEEN IN ITEM E-223 IS NOT VISIBLE IN THIS ITEM. CONDENSATE FROM THE ET AFT DOME VAPORIZES DURING EARLY ASCENT.

E-204 PAFB IGOR tracking of launch vehicle from
48 FPS acquisition to SRB separation. Tracks ET/ORB
35mm after SRB separation to LOV.

Focus : SOFT
F. O. V.: OK
Exposure: OK

Comments: PLUME RECIRCULATION PHENOMENON AROUND ET AFT DOME BEGINS AT FRAME 4065 AND APPEARS BEHIND -Z SIDE OF SRB BY FRAME 4620. BSM FIRING/SRB SEPARATION OCCURS AT FRAME 5355 - NO ANOMALIES ARE VISIBLE.

E-205 Shiloh IFLOT tracking of launch vehicle from
48 FPS acquisition to SRB separation. Tracks ET/ORB
35mm after SRB separation to LOV.

Focus : SOFT DUE TO ATMOSPHERIC EFFECTS
F. O. V.: OK
Exposure: SLIGHTLY UNDEREXPOSED

Comments: TRACKS VEHICLE WELL THROUGH SRB SEPARATION. DUE TO HAZE AND CLOUDS, VEHICLE DETAIL WAS NOT FINE ENOUGH FOR RESOLUTION OF DEBRIS.

E-206 Melbourne Beach ROTI tracking of launch vehicle
48 FPS from acquisition to SRB separation. Tracks ET/ORB
35mm after SRB separation to LOV.

Focus : SOFT
F. O. V.: ERRATIC TRACKING
Exposure: UNDEREXPOSED

Comments: PLUME RECIRCULATION PHENOMENON AROUND ET AFT DOME BEGINS AT FRAME 3737 AND APPEARS ON -Z SIDE OF SRB BY FRAME 4485. BSM FIRING/SRB SEPARATION OCCURS AT FRAME 5145. DUE TO HAZE AND CLOUDS, NO VEHICLE DEBRIS PARTICLES ARE DISCERNIBLE.

E-207 UCS-10 MIGOR tracking of launch vehicle from
96 FPS acquisition to SRB separation. Tracks ET/ORB
35mm after SRB separation to LOV.

Focus : SOFT, PROBABLY DUE TO ATMOSPHERIC HAZE
F. O. V.: OK, BUT IMAGE IS REVERSED
Exposure: OK

Comments: AERODYNAMIC SHOCK EXPANSION WAVE IS MADE VISIBLE BY CONDENSATION (FRAME 1404). SRB SEPARATION OCCURS AT FRAME 9407. NO VEHICLE ANOMALIES NOTED.

E-208 Cocoa Beach DOAMS tracking of launch vehicle
48 FPS from acquisition to SRB separation. Tracks ET/ORB
35mm after SRB separation to LOV.

Focus : HAZY IMAGE DUE TO ATMOSPHERIC EFFECTS
F. O. V.: ERRATIC TRACKING
Exposure: OK

Comments: PLUME RECIRCULATION PHENOMENON OCCURS AROUND ET AFT DOME AT FRAME 2086. SRB SEPARATION MISSED BY TRACKER. HOWEVER, BSM FIRING WAS VISIBLE AND NO LOOSE PARTICLES OR DEBRIS CONCERNS OCCURRED.

E-209 UCS-13 IFLOT intermediate tracking of
30 FPS launch vehicle from acquisition to LOV.
70mm

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED

Comments: NO VEHICLE ANOMALIES NOTED. VIEW OF VEHICLE LOST EARLY IN ASCENT DUE TO CLOUD COVER.

E-210 UCS-26 IFLOT intermediate tracking of
30 FPS launch vehicle from acquisition to LOV.
70mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: NO VEHICLE ANOMALIES NOTED. VIEW OF VEHICLE LOST
EARLY IN ASCENT.

E-211 UCS-13 IFLOT intermediate tracking of forward
96 FPS portion of ORB and ET from acquisition to LOV.
35mm

Focus : SOFT DUE TO ATMOSPHERIC HAZE
F. O. V.: OK
Exposure: SLIGHTLY UNDEREXPOSED

Comments: CHARRING HAS OCCURRED AROUND THE AFT DOME MANHOLE
COVERS. DUE TO HAZE, VEHICLE DETAIL WAS NOT DISCERNIBLE FOR
RESOLUTION OF DEBRIS.

E-212 UCS-23 MIGOR tracking of launch vehicle
96 FPS from acquisition to LOV.
35mm

Focus : SOFT
F. O. V.: OK
Exposure: UNDEREXPOSED

Comments: DUE TO HAZE AND CLOUDS, FINE DETAIL WAS NOT DISCERN-
IBLE.

E-213 UCS-7 MOTS tracking of forward portion of ORB and
96 FPS ET from acquisition to LOV.
35mm

Comments: FILM JAMMED AT CAMERA START.

E-217 Beach Road IFLOT close-in tracking of launch
30 FPS vehicle during ignition, liftoff, and early
70mm portion of flight through LOV.

Focus : OK
F. O. V.: OK
Exposure: SLIGHTLY UNDEREXPOSED

Comments: SAME AS E-222.

E-218 UCS-26 IFLOT intermediate tracking of
96 FPS launch vehicle from acquisition through LOV.
35mm

Focus : SOFT
F. O. V.: OK
Exposure: UNDEREXPOSED

Comments: DUE TO HAZE AND CLOUD LAYERS, FINE DETAIL WAS NOT
DISCERNIBLE. NO VEHICLE ANOMALIES.

E-219 UCS-3 IFLOT close-in tracking of launch
30 FPS vehicle during ignition, liftoff, and early
70mm portion of flight through LOV.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: SAME COMMENTS AS E-221. SRB SEPARATION OBSCURED BY
CLOUD COVER.

E-220 UCS-15 IFLOT close-in tracking of launch
96 FPS vehicle during ignition, liftoff, and early
35mm portion of flight through LOV.

Focus : SOFT
F. O. V.: OK
Exposure: OK

Comments: MAX 'Q' CONDENSATE EXPANSION WAVE FORMS ON ORBITER
CREW CABIN AND LH SRB FORWARD ASSEMBLY. FWD LH RCS PAPER COVERS
PULL LOOSE AT THREE LOCATIONS (FRAMES 1119, 3154). NO VEHICLE
ANOMALIES.

E-221 UCS-3 IFLOT close-in tracking of forward portion
96 FPS of ORB and ET during ignition, liftoff, and early
35mm portion of flight through LOV.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: WATER FROM SRB STIFFENER RINGS VAPORIZES. LH2 AFT DOME CHARS EARLY. RCS PAPER COVERS ARE INTACT ON LH FWD RCS (FRAME 1172). RCS PAPER COVERS FROM LH FWD RCS FALL INTO SSME PLUME (FRAME 1405). A FLASH OCCURS IN SSME PLUME (FRAME 1923). SEVEN DEBRIS OBJECTS, POSSIBLY RCS PAPER COVERS, ARE VISIBLE IN SSME PLUME (FRAME 1978). DEBRIS PARTICLES BURN IN SSME PLUME (FRAME 2472). A FLASH OCCURS IN SSME PLUME (FRAME 3594). ANOTHER FLASH IS VISIBLE IN SSME PLUME AT FRAME 3599. ONE MORE FLASH OCCURS IN SSME PLUME (FRAME 3637).

E-222 Beach Road IFLOT close-in tracking of forward
96 FPS portion of ORB and ET during ignition, liftoff,
35mm and early portion of flight through LOV.

Focus : OK
F. O. V.: OK
Exposure: SLIGHTLY UNDEREXPOSED

Comments: WATER/CONDENSATE FROM ET AFT DOME AND SRB STIFFENER RINGS VAPORIZES. ET AFT DOME BEGINS TO CHAR BY ROLL MANEUVER.

18:47:04.30 DEBRIS FALLS AFT OF VEHICLE IN SSME PLUME
18:47:12.76 RCS PAPER COVER FROM LH FWD RCS TRAVELS DOWN
SIDE OF ORBITER
18:47:14.20 RCS PAPER COVER SEPARATES FROM FWD RCS
18:47:14.83 LARGE OBJECT APPEARS AFT OF LH WING AND FALLS
BETWEEN SRB'S (MAY BE EVENT SEEN IN E-223)
18:47:17.54 SEVERAL PARTICLES FALL AFT OF RH WING INTO SSME
PLUME
18:47:20.66 PARTICLE APPEARS AFT OF BODY FLAP
18:47:20.97 PARTICLE ORIGINATES FROM RH SRB BSM AREA AND
FALLS AFT
18:47:22.54 SEVERAL PIECES OF DEBRIS APPEAR BETWEEN SRB'S
18:47:22.94 SEVERAL PIECES OF DEBRIS (INSTAFOAM) ADJACENT
TO RH SRB PLUME
18:47:23.25 PARTICLES BREAK UP AFT OF VEHICLE IN SSME PLUME
18:47:23.63 INSTAFOAM PARTICLES FALL AFT OF RH SRB
18:47:23.78 INSTAFOAM PARTICLES APPEAR BETWEEN SRB'S
18:47:23.80 SEVERAL DEBRIS PARTICLES AFT OF SSME #1
18:47:25.42 DEBRIS FALLS AFT OF VEHICLE BETWEEN SRB'S
18:47:27.80 DEBRIS FALLS AFT OF VEHICLE BETWEEN SRB'S
18:47:33.03 DEBRIS FALLS AFT OF RH WING AND IS VISIBLE
SUBSEQUENTLY AS A CLOUD OF MANY SMALLER PIECES

E-223
96 FPS
35mm

UCS-9 IFLOT intermediate tracking of forward
portion of ORB and ET during ignition, liftoff,
and early portion of flight through LOV.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: A PIECE OF DEBRIS, POSSIBLY PART OF THE ET/ORB UMBILI-
CAL BAGGIE WITH ICE ATTACHED FALLS AFT AND BREAKS INTO SEVERAL
PIECES (FRAME 1350). IT DOES NOT APPEAR TO IMPACT THE ORBITER
TILES OR CAUSE ANY VEHICLE DAMAGE. SEVERAL PIECES OF DEBRIS ARE
VISIBLE IN THE SSME PLUME AT FRAME 2484. SEVERAL MORE PIECES OF
DEBRIS, VERY BRIGHT AND INTENSE, ARE VISIBLE IN THE SSME PLUME.
THIS DEBRIS ORIGINATES FORWARD OF THE RH OMS POD. ONE DEBRIS
PARTICLE (FRAME 3126) AND TWO MORE DEBRIS PARTICLES (FRAME 3469)
ARE VISIBLE IN THE SSME PLUME. THE AERODYNAMIC SHOCK EXPANSION
WAVE FORMED ON THE RH SRB FRUSTUM IS VISIBLE BY CONDENSATION.

E-233
35mm

Castglance

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: CHUFFING OCCURS FOR MOST OF THE DESCENT. THE FRUSTUM
COCKS SLIGHTLY JUST BEFORE THE PARACHUTES ARE PULLED OUT, BUT NO
DIRECT EFFECT ON CHUTE INFLATION IS VISIBLE. THE FIRST PARACHUTE
BEGINS TO INFLATE, THEN COLLAPSES AND NEVER REOPENS. THE OTHER 2
PARACHUTES INFLATE WITH NO PROBLEMS. SMOKE FROM THE NOZZLE EXTEN-
SION SEVERANCE STREAMS PAST THE BOOSTER CASE, BUT THE ACTUAL
SEPARATION OF THE NOZZLE IS NOT IN THE FOV.

E-234
16mm

Castglance

Focus : SOFT DUE TO ATMOSPHERIC EFFECTS
F. O. V.: OK
Exposure: OK

Comments: THIS CAMERA ALSO VIEWS THE LH SRB. SEE COMMENTS FOR
E-233.

E-301 RH SRB Parachute deployment
200 FPS
16mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: FRUSTUM SEPARATION APPEARS NORMAL. MANY SMALL PIECES OF RED AND WHITE COLORED DEBRIS ARE VISIBLE IN THE VICINITY OF THE FOLDED PARACHUTES. AFTER CHUTE DEPLOYMENT, LOOSE RESTRAINING CORD ENTERS FOV. THE FIRST PARACHUTE INFLATES AT FRAME 3571, THE SECOND AT 3678, AND THE THIRD IS OBSCURED BY NOZZLE SEVERANCE SMOKE, WHICH IS FIRST VISIBLE AT FRAME 3490. THIN, FLAT, DARK COLORED DEBRIS, POSSIBLY NOZZLE MATERIAL, BREAKS LOOSE DURING NOZZLE SEVERANCE AND FLIES UPWARD TOWARD PARACHUTES. PARTICULARLY LARGE PIECES ARE VISIBLE AT FRAMES 5084, 4856, AND 4385, WHICH REBOUNDS ON THE SRB FORWARD DOME.

E-302 LH SRB Parachute deployment
200 FPS
16mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: FRUSTUM SEPARATION APPEARED NORMAL. LOOSE RESTRAINING CORD ENTERS FOV. THE FIRST PARACHUTE INFLATES BY FRAME 2550 AND THE SECOND BY FRAME 3480. THE THIRD PARACHUTE WAS ACTUALLY GOING TO BE THE FIRST TO INFLATE, BUT INSTEAD COLLAPSED AND NEVER REOPENED. THE FIRST SIGNS OF NOZZLE SEVERANCE OCCUR AT FRAME 3580 WITH DARK SMOKE FOLLOWED BY NUMEROUS PIECES OF NOZZLE MATERIAL.

MAG 60 Debris Camera in Pilot's Window #4
16mm

Focus : OK
F.O.V. : OK
Exposure: OK

Comments: VEHICLE VIBRATION IS VISIBLE DURING SSME IGNITION. ORBITER MOVEMENT RELATIVE TO THE ET OCCURS AT FRAME 970 FOLLOWED BY ROLL PROGRAM AT FRAME 1820. FWD RCS PAPER COVERS RUPTURE IN FRAMES 2214-2356, 2356-2376, 2407-2441, AND 4374-4394. THE COVERS BEGINS TO RUPTURE JUST AFTER THE ROLL MANEUVER, BUT DO NOT LEAVE STREAKS ON THE WINDOW. SRB SEPARATION OCCURS FROM FRAME 13,766 THROUGH 13,890. THE INITIAL MIXTURE OF BSM EXHAUST PLUMES CLEARLY

SEPARATE AS EACH BOOSTER MOVES AWAY FROM THE ORBITER. A FEW SMALL PARTICLES OF FOAM ARE DISLODGED FROM THE ET AND SOME BSM RESIDUE ADHERES TO THE WINDOW.

E-1001 Orbiter landing at Ames-Dryden FRC.
16mm

Focus : OK
F.O.V. : ERRATIC TRACKING
Exposure: OK

Comments: CAMERA MOVEMENT AND ERRATIC TRACKING PREVENTED DETAILS FROM BEING DISCERNABLE.

E-1002 Orbiter landing at Ames-Dryden FRC.
16mm

Focus : OK
F.O.V. : OK
Exposure: SLIGHTLY OVEREXPOSED

Comments: LANDING GEAR DEPLOYMENT IS NOMINAL. NO ORBITER ANOMALIES ARE VISIBLE DUE TO THE DISTANT VIEW.

E-1005 Orbiter landing at Ames-Dryden FRC.
35mm

Focus : SLIGHTLY SOFT
F.O.V. : OK
Exposure: OK

Comments: DURING FINAL APPROACH, A THIN WHITE, LOW DENSITY OBJECT FIRST APPEARS IN THE VICINITY OF THE LH OMS POD AREA AND IS SWEEPED AFT BY THE AIRSTREAM (28:19:42:51, APPROXIMATELY 17 SECONDS PRIOR TO LANDING GEAR DEPLOYMENT). SINCE NO WHITE TILES WERE MISSING, IT IS MOST LIKELY A PIECE OF THE THERMAL BARRIER FROM THE SSME HORSECOLLAR. LANDING GEAR IS EXTENDED AT 28:19:43:08. THE RH MAIN LANDING GEAR TOUCHES DOWN SLIGHTLY AHEAD OF THE LH MLG.

E-1006 Orbiter landing at Ames-Dryden FRC.
16mm

Focus : SOFT
F.O.V. : OK
Exposure: OK
Comments: SEE COMMENTS FOR E-1008.

E-1008 Orbiter landing at Ames-Dryden FRC.
35mm

Focus : SLIGHTLY SOFT
F.O.V. : OK
Exposure: OK

Comments: DURING FINAL APPROACH A THIN, WHITE, LOW DENSITY
OBJECT FIRST APPEARS IN THE VICINITY OF THE LH OMS POD AREA AND
IS SWEEPED AFT BY THE AIRSTREAM (FRAME 1841 - APPROXIMATELY 17
SECONDS PRIOR TO LANDING GEAR DEPLOYMENT). SINCE NO WHITE TILES
WERE MISSING, IT IS MOST LIKELY A PIECE OF THE THERMAL BARRIER
FROM THE SSME HORSECOLLAR. THE RH MAIN LANDING GEAR TOUCHES DOWN
FIRST FOLLOWED ALMOST IMMEDIATELY BY THE LH MLG.

E-1009 Orbiter landing at Ames-Dryden FRC.
16mm

Focus : SOFT
F.O.V. : OK
Exposure: OK

Comments: SEE COMMENTS FOR E-1005.

S E

E-1011 Orbiter landing at Ames-Dryden FRC.

Focus : OK
F.O.V. : OK
Exposure: OK

Comments: NO ANOMALIES, THOUGH ATMOSPHERIC HAZE AND HEAT WAVES
MADE RESOLUTION OF FINE DETAIL DIFFICULT.

E-1012 Orbiter landing at Ames-Dryden FRC.
16mm

Focus : OK
F.O.V. : OK
Exposure: OK

Comments: LANDING GEAR DEPLOYMENT IS NOMINAL. NO ORBITER ANOMALIES ARE VISIBLE DUE TO THE DISTANT VIEW.

VIDEO ITEMS

CASTGLANCE ET reentry and breakup
B/W U-matic

Comments: VIEW IS TOO DISTANT FOR RESOLUTION OF STRUCTURAL DETAIL, BUT THE ET BREAKUP SEQUENCE IS TYPICAL STARTING WITH LH2 TANK RUPTURE FOLLOWED BY FRICTIONAL EROSION OF THE LO2 TANK.

OTV 101 Views aft end of Orbiter from the FSS 255 foot
B/W M-II level.

Comments: SMOKE FROM ROFI IS BLOWN TOWARD FSS. ORBITER LH2 T-0 UMBILICAL DISCONNECT IS NOMINAL. RESIDUAL VAPORS EMANATE FROM QD'S.

OTV 103 Views GUCP and GH2 vent line.
B/W M-II

Comments: ICE/FROST PARTICLES FALL FROM GUCP DURING 'TWANG'. GUCP DISCONNECT AND SEPARATION IS NOMINAL. STREAKS ON LH SRB CASE ARE CAUSED BY RUSTY WATER FROM THE FACILITY DELUGE.

OTV-109 Views ET/Orbiter LH2 umbilical area from the 95
B/W M-II foot level of the FSS.

Comments: NORMAL PURGE VENTING OCCURS ON ET/ORB LH2 UMBILICAL. WATER DELUGE SPRAY AND ROFI SMOKE PARTIALLY OBSCURES VIEW. SSME STARTUP VIBRATION CAUSES ICE AND FROST PARTICLES TO FALL FROM UMBILICAL BAGGIE. LIFTOFF CAUSES A SECOND SHOWER OF ICE/FROST PARTICLES FROM THE SAME AREA TO FALL PAST BODY FLAP, BUT NO DAMAGE TO ORBITER TILES IS VISIBLE.

OTV 111 Views GUCP and GH2 vent line with new Insight IR
B/W IR camera.

Comments: TURNED AWAY FROM VEHICLE - NO DATA.

OTV 119 Views LH2 umbilical with new Insight IR camera.
B/W IR

Comments: TURNED AWAY FROM VEHICLE - NO DATA.

OTV 130 Views SSMEs and Orbiter aft end from SE pad apron
B/W IR with new Insight IR camera.

Comments: TURNED AWAY FROM VEHICLE - NO DATA.

OTV 141 Views and tracks vehicle from camera site 2.
B/W

Comments: T-0 OCCURS AT 18:46:58 WITH LOV AT T+25 SECONDS. NO
DEBRIS OR VEHICLE ANOMALIES.

OTV 143 Views east side of launch vehicle and pad from
B/W camera site 2.

Comments: GOOD VIEW OF VEHICLE TWANG. AEC UNDEREXPOSES VIEW.

OTV 148 Launch and tracking view from camera site 6.
B/W

Comments: TRACKING IS ERRATIC. WHAT LOOKS LIKE VAPOR ON -Z SIDE
OF ET IS GHOST IMAGE OF SRB PLUME DUE TO OPTICAL EFFECTS. NO
DEBRIS OR VEHICLE ANOMALIES ARE VISIBLE.

OTV 149 Views Orbiter LO2 T-0 umbilical from MLP deck.
B/W M-II

Comments: DISCONNECT AND RETRACTION OF ORBITER LO2 T-0 UMBILICAL
IS NOMINAL.

OTV 150 Views Orbiter LH2 T-0 umbilical from SW MLP deck.
B/W M-II

Comments: DISCONNECT AND RETRACTION OF ORBITER LH2 T-0 UMBILICAL IS NOMINAL.

OTV 151 Views main engine cluster.
B/W M-II

Comments: VENTED GOX IS BLOWN TOWARD LH2 TSM. SSME IGNITION IS NORMAL. GOX CLOUD FROM T-0 UMBILICAL DISCONNECT IS PULLED INTO SSME PLUME ALONG WITH PIECES OF RCS PAPER COVERS. NO SRB ANOMALIES.

OTV 154 Views ET/Orbiter LO2 umbilical and Orbiter RH wing
B/W M-II

Comments: ICE FALLS AT SSME IGNITION AND T-0 FROM BOTH ET/ORB UMBILICALS, BUT NO DAMAGE TO TILES IS VISIBLE. MISSING TILE PIECE FROM BODY FLAP HINGE AREA IS NOT VISIBLE IN THIS ITEM.

OTV 155 Views RH SRB and underside of Orbiter RH wing.
B/W M-II

Comments: ICE FALLS AT SSME IGNITION AND T-0 FROM BOTH ET/ORB UMBILICALS, BUT NO DAMAGE TO TILES IS VISIBLE. MISSING TILE PIECE FROM BODY FLAP HINGE AREA PASSES SSME #3 NOZZLE SHORTLY AFTER SSME IGNITION.

OTV 156 Views LH SRB and underside of Orbiter LH wing.
B/W M-II

Comments: VIEW IS UNDEREXPOSED DUE TO AEC. ROFI SMOKE IS BLOWN TOWARD FSS. ICE FALLS AT SSME IGNITION AND T-0 FROM BOTH ET/ORB UMBILICALS.

OTV 160 Views ET nosecone and NE louver from water tower.
Color M-II

Comments: NO ET FOOTPRINT ANOMALIES OR ICE ON LOUVER. VIRTUALLY NO GOX VAPORS EMANATE FROM THE LOUVER. NO DEBRIS OR VEHICLE ANOMALIES ARE VISIBLE.

OTV 161 Views ET nosecone and SW louver from the FSS.
Color M-II

Comments: NO ET FOOTPRINT ANOMALIES OR ICE ON LOUVER. ICE/FROST PARTICLES CONTINUE TO FALL FROM ET/ORB UMBILICALS AS VEHICLE PASSES.

OTV 163 Views ET/Orbiter umbilical and Orbiter LH2 T-0
Color M-II umbilical from the FSS.

Comments: WATER DELUGE SPRAY FROM FSS ENTERS FOV. AS SSME'S IGNITE, AT LEAST THREE LARGE PIECES OF ICE FALL FROM ET/ORB LH2 UMBILICAL WITH NO APPARENT TILE DAMAGE. AT THE SAME TIME, VAPORS EMANATE FROM THE LH2 RECIRCULATION LINE (ET SIDE) BELLOW. NORMAL PURGE VENTING OCCURS AROUND THE LH2 UMBILICAL. ONE LARGE OBJECT FALLS FROM THE LO2 FEEDLINE BELLOW AREA - PROBABLY ICE. ORBITER LH2 T-0 UMBILICAL DISCONNECT IS NOMINAL. NO SRB ANOMALIES.

OTV 170 Views overall vehicle from SE direction.
Color M-II

Comments: RUSTY DELUGE WATER IS SPRAYED ON THE MLP SOUTH SIDE. ROFI ACTIVATION IS NORMAL. STRONG EAST WIND BLOWS BURNING FREE HYDROGEN TOWARD LH2 TSM. RCS PAPER COVERS TEAR BEFORE SSME PLUMES HAVE STABILIZED. VERTICAL TAIL EXPERIENCES SIDE TO SIDE VIBRATION, BUT DAMPEN PRIOR TO T-0. MANY PIECES OF RCS PAPER COVERS AND ICE FROM LO2 T-0 UMBILICAL ARE PULLED INTO SSME PLUME. SSME IGNITION AND ORBITER T-0 DISCONNECT ARE NOMINAL.

OTV 171 Views overall vehicle from SW direction.
Color M-II

Comments: DISTANT VIEW - NO VEHICLE ANOMALIES ARE VISIBLE. EAST WIND BLOWS PLUME TOWARD RSS. NO SLIDEWIRE BASKETS ARE RELEASED AT SSME IGNITION UNTIL LOV.

OTV 172 Views SSMEs with new Insight IR camera from SW
B/W IR corner of MLP deck.

Comments: TURNED AWAY FROM VEHICLE - NO DATA.

STI (C/S 2) Infrared view from camera site 2.
B/W M-II

Comments: APU START AND RUN IS NORMAL WITH EAST WIND BLOWING EXHAUST GENERALLY AWAY FROM VEHICLE. SSME IGNITION IS NOMINAL. VERTICAL TAIL AND BASE HEAT SHIELD BEGIN TO ACCUMULATE THERMAL ENERGY ALMOST IMMEDIATELY.

STI (RSS) Infrared view from RSS roof.
B/W M-II

Comments: APU START AND RUN IS NORMAL WITH LITTLE THERMAL IMPINGEMENT OF PAYLOAD BAY DOORS. SSME IGNITION IS ALSO NOMINAL.

TV-1 Views launch from SLF.
Color M-II

Comments: DISTANT VIEW - NO VEHICLE ANOMALIES.

TV-2 Views entire launch vehicle from camera site 7
Color M-II east of Pad B.

Comments: DISTANT VIEW - NO VEHICLE ANOMALIES. LITTLE EFFECT OF VEHICLE EXHAUST PLUME BY WINDS ALOFT.

TV-3 Views entire launch vehicle from camera site 9
Color M-II

Comments: DISTANT VIEW - NO VEHICLE ANOMALIES. SRB SEPARATION APPEARS NOMINAL.

TV-4 Views entire vehicle from Beach Road IFLOT Site.
Color M-II

Comments: RUSTY DELUGE WATER IS SPRAYED ON MLP SOUTH SIDE LH2 SKID. SSME IGNITION IS NORMAL. A BIRD ENTERS THE FOV TO THE RIGHT OF THE RH SRB BETWEEN THE CAMERA AND THE VEHICLE, BUT IS THEN LOST AGAINST THE BACKGROUND. HOWEVER, THE BIRD WAS FAR ENOUGH AWAY FROM THE VEHICLE TO PRECLUDE A STRIKE. CONDENSATE VAPOR FROM

ET AFT DOME AND SRB STIFFENER RINGS HAS CLEARED BY ROLL PROGRAM.
AFT DOME BEGINS TO CHAR DURING ROLL MANEUVER. TWO FLASHES OCCUR
IN SSME PLUME WELL AFTER ROLL.

TV-5 Views launch from VAB roof.
Color M-II

Comments: DISTANT VIEW - NO VEHICLE ANOMALIES.

TV-6 Views entire launch vehicle from DLTR-3 site
Color M-II directly south of Pad B.

Comments: THREE BIRDS ARE IN THE FOV, BUT NOT NEAR THE VEHICLE.
WATER FROM THE SRB STIFFENER RINGS VAPORIZES, BUT NO VAPORS
EMANATE FROM THE ET/ORB UMBILICALS. NO DEBRIS CONCERNS. SRB
SEPARATION APPEARS NOMINAL.

TV-7 Views entire launch vehicle from camera site 2
Color M-II east of pad.

Comments: TIGHT VIEW OF CREW CABIN - NO TRACKING AFTER LAUNCH.
WATER DELUGE TO THE RIGHT OF VEHICLE ORIGINATES FROM ET INTERTANK
ACCESS STRUCTURE. NO VAPORS EMANATE FROM ET/ORB UMBILICALS DURING
ASCENT. ONE ICE PARTICLE IS VISIBLE FALLING FROM ET/ORB UMBILICAL
AREA.

TV-13 Cocoa Beach DOAMS video. Tracks launch vehicle
Color M-II from acquisition to LOV.

Comments: INITIAL VIEW IS AT 18:49:38 AFTER SRB SEPARATION HAS
OCCURRED. REMAINING FOOTAGE IS OF SSME PLUME. NO USEFUL DATA.

TV-16 View from helicopter orbiting west of pad and VAB.
Color M-II

Comments: DISTANT VIEW - NO VEHICLE ANOMALIES.

TV-18 Malabar ITEC video. Tracks launch vehicle from
Color M-II acquisition to LOV.

Comments: VIEW IS DISTANT AND HAZY, BUT RECIRCULATION PHENOMENON AROUND ET AFT DOME IS WELL DEFINED. CLOUDS OBSCURE SRB SEPARATION.

ET-204 Patrick IGOR video. Tracks launch vehicle from Color M-II acquisition to LOV.

Comments: EARLY VIEW OF THE VEHICLE IS OBSCURED BY CLOUDS AND HAZE. RECIRCULATION PHENOMENON OCCURS FROM 18:48:35 TO 18:48:50. AT 18:49:04.025, BSM'S FIRE. NO DEBRIS OR SLAG OBSERVED AT SRB SEPARATION.

ET-206 Melbourne Beach DOAMS video. Tracks launch vehicle Color M-II from acquisition to LOV.

Comments: ACQUISITION WAS LATE AND EARLY VIEWS OF VEHICLE WERE OBSCURED BY CLOUDS AND HAZE. RECIRCULATION PHENOMENON OCCURS FROM 18:48:35 TO 18:48:49. AT 18:49:04, BSM'S FIRE. NO DEBRIS OR SLAG IS OBSERVED AT SRB SEPARATION.

ET-207 UCS-10 IGOR video. Tracks launch vehicle from Color M-II acquisition to LOV.

Comments: BIRDS ENTER FOV PRIOR TO T-0, BUT ARE NOT NEAR THE VEHICLE. EARLY VIEWS OF VEHICLE ARE OBSCURED BY CLOUDS AND HAZE. NO TIMING AVAILABLE ON TAPE. GOOD TRACKING OF VEHICLE. MPS PLUME IS REFLECTED ON UNDERSIDE OF WINGTIP AND OMS POD. NO DEBRIS IS VISIBLE AT SRB SEPARATION, BUT TWO PIECES OF SLAG FALL FROM LH SRB SHORTLY AFTER SEPARATION.

ET-208 Cocoa Beach DOAMS video. Tracks launch vehicle Color M-II from acquisition to LOV.

Comments: DOAMS FAILED AT T-5 MINUTES.

ET-212 UCS-23 MIGOR video. Tracks launch vehicle from Color M-II acquisition to LOV.

Comments: TRACKING IS RELATIVELY SHORT AND THERE IS NO TIMING AVAILABLE ON THE TAPE. EARLY VIEWS OF VEHICLE ARE OBSCURED BY CLOUDS AND HAZE.

ET-213 UCS-7 MOTS video. Tracks launch vehicle from
Color M-II acquisition to LOV.

Comments: EXCELLENT VIEW AND GOOD TRACKING. SUNLIGHT IS
REFLECTED OFF ORBITER FWD WINDOWS AT 18:47:09.

9.0 SRB POST FLIGHT/RETRIEVAL DEBRIS ASSESSMENT

Both Solid Rocket Booster frustums and the dome of the RH nose cap were inspected for debris damage and sources at CCAFS Hangar AF on 7 May 1989 from 0830 to 1130 hours. Other than the RH nose cap dome, the booster nose caps were not recovered and are therefore not included in this assessment. The recovered nose cap dome showed no ablator adhesion problems.

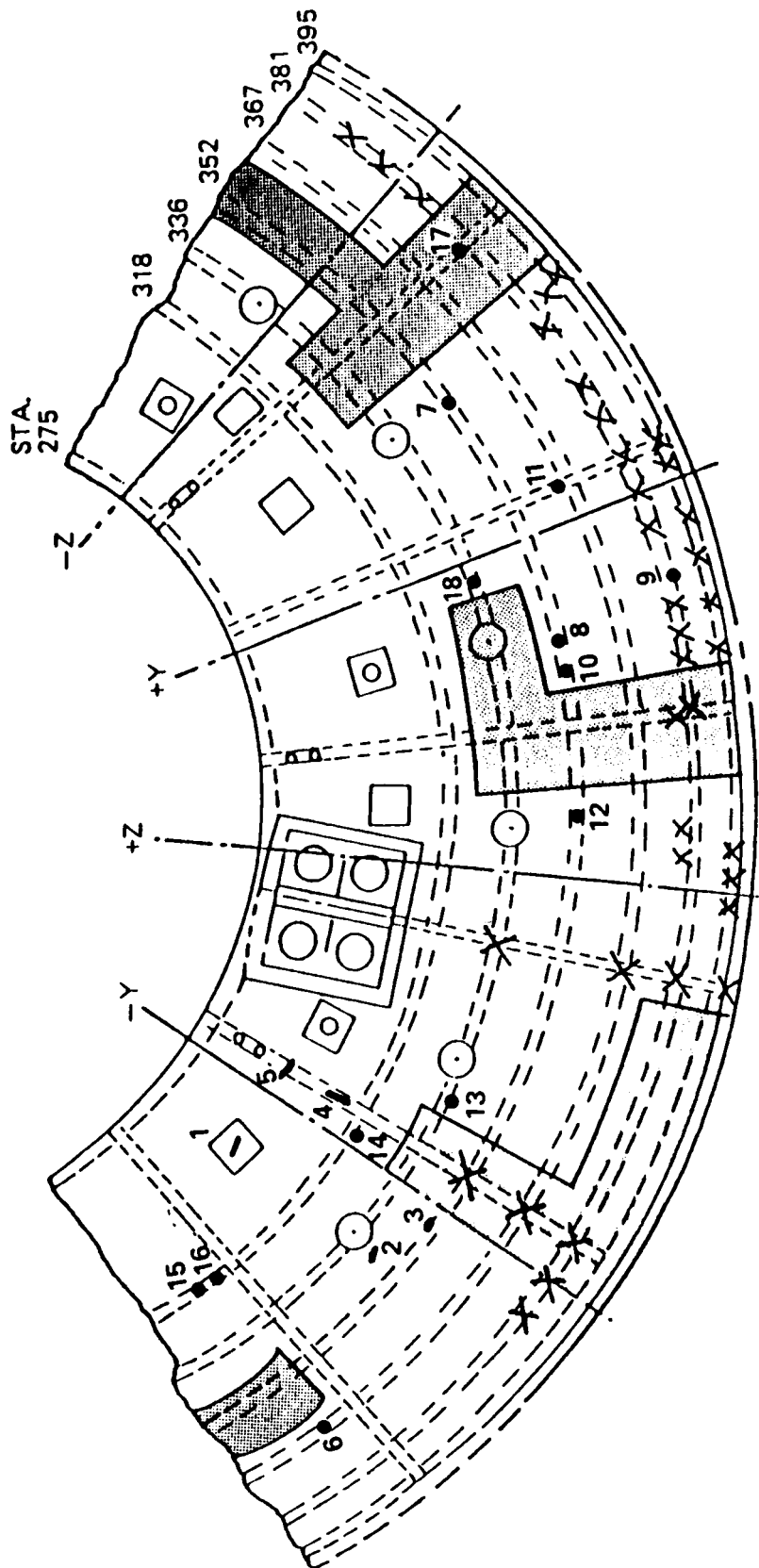
9.1 RH SOLID ROCKET BOOSTER DEBRIS INSPECTION

The RH frustum was not missing any MSA-2 TPS but did exhibit 81 debonds, all of which occurred over the sealant caps (Figure 11). Removal of the debonded areas revealed adhesive failure of epoxy topcoat to the sealant cap outer surface. Further inspection revealed separation of the sealant caps from the PR1422 sealant. Moisture was found at many of the separation interfaces. The debond phenomenon is probably caused by incompatibility of MSA-2 solvents in contact with the santoprene rubber cap material during spray operations. One acreage debond had occurred. Hypalon paint blisters, with MSA-2 ablator attached to the paint, occurred on the 381 and 395 rings. There were numerous blisters in the hypalon paint averaging 1/8-inch to 1/2-inch in the white areas and 1/8-inch to 5-inches in the black visibility stripes. All BSM covers were intact and locked in the open position.

The RH FWD skirt exhibited missing MSA-2 TPS (3"x1.5", 4"x2") to substrate at two locations and one debond (2.5") as shown in Figure 12. The hypalon paint was generally in good condition with some blistering in the black visibility stripe. Several 1/16 to 3/4-inch chips were visible in the RSS antenna closeout and on the antenna ablator. The cork was blistered/exposed in 25 areas measuring 1/8 to 3/4-inch in diameter near the thrust post. Approximately 80% of these areas showed signs of heating. Phenolic plates on both RSS antennas were intact. Separation of the forward attach fitting was nominal and the RSS cables separated cleanly.

All factory and field joint closeouts were undamaged. Known void areas on the field joint closeout repairs remained intact. Trailing edge damage to DFI cork runs was attributed to debris from nozzle extension severance. A 6-inch longitudinal scrape was present at the forward skirt joint closeout 300 degree location and probably occurred from nozzle extension debris. Numerous GEI MSID labels were missing. Of the 40 labels on the RH SRM, 15 were totally missing (7 showed signs of soot), 14 were partially missing (2 showed signs of soot), and only 11 were completely intact. The epoxy closeout over the labels, generally 6"x1-1/4"x1/8-inch thick, is a debris concern. Action is presently being taken to correct this problem on future

FIGURE 11. RIGHT SRB FRUSTUM



MISSING TPS

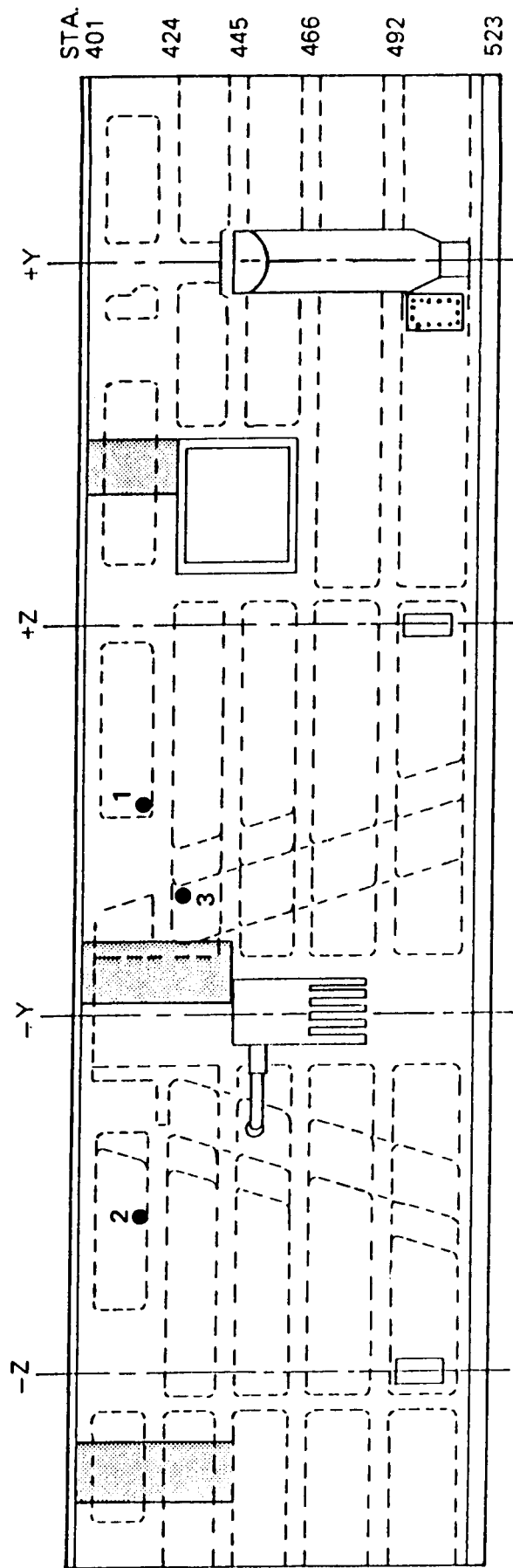
NONE

DEBONDS

- 1) 1½" CRACK WITH OFFSET
- 2) 1½"x ¾" TO SUBSTRATE
- 3) 1" x 2"
- 4) 3" x 4"
- 5) 1½" CRACK WITH OFFSET
- 6) 2½" CRACK WITH 1½" VERT OFFSET
- 7) 1½" x 1"
- 8-18) 1" x 1½"
- 19-81) SMALL RANDOM DEBONDS OVER SEALANT CAP LOCATIONS

X - MISSING HYPALON PAINT AREAS

FIGURE 12. RIGHT SRB FWD SKIRT



TPS MISSING

- 1) 3" x 1½" TO SUBSTRATE
- 2) 4" x 2" TO SUBSTRATE

DEBONDS

- 3) 2½" x ¾" TPS CRACKED BUT STILL INTACT

flights. Accessible labels will be replaced by stencils on the 5th flight set. All labels are to be removed from the 6th flight set and GEI ID information stenciled on the case.

Separation of the aft ET/SRB struts was nominal. One electrical connector at the upper strut separation plane experienced a bent housing. K5NA was cracked in the forward stiffener ring. Some TPS was missing from the ET attach ring.

The kick ring phenolic material delaminated at the 180 and 270 degree locations. K5NA was missing from all four BSM nozzles (Figure 13). The TPS over the aft skirt acreage was generally in good condition, but exhibited the typical 'popcorning'. The TVC system was virtually undamaged. Some of the holddown post #4 shim was missing and the substrate was charred.

9.2 LH SOLID ROCKET BOOSTER DEBRIS INSPECTION

The LH frustum was not missing any MSA-2 TPS but did exhibit 104 debonds, which had occurred over the sealant caps (Figure 14). Removal of the debonded areas revealed adhesive failure of the epoxy topcoat to the sealant cap outer surface. Further inspection revealed separation of the sealant cap from the PR1422 sealant. Moisture was found at many of the separation interfaces. The debond phenomenon was probably caused by incompatibility of the MSA-2 solvents in contact with the santoprene rubber cap material during spray operations. The largest debond measured 8"x3". Most of the Hypalon paint blisters, with ablator material attached to the paint, occurred on the 395 ring. All BSM covers were intact and locked in the open position.

The LH FWD skirt exhibited debonded and missing (2"x1") ablator on the aft edge of the banjo fitting. Sooted cork was visible in the divot. There were no debonds (Figure 15). The phenolic plate was delaminated on the +Z RSS antenna while the -Z antenna sustained a crack and missing piece (1"x1/2") on the aft end of the SLA 220. There were some areas of blistered Hypalon paint on the thrust post and black visibility stripe. Separation of the forward attach fitting was nominal.

All field joint closeouts were undamaged and known void areas in field joint closeout repairs were still intact. Three of the LH SRM factory joint weather seals showed signs of aft edge debond regions. Trailing edge damage to the DFI cork runs was attributed to debris from the nozzle extension severance. Numerous GEI MSID labels were missing. Of the 40 labels on the LH SRM, 27 were totally missing (15 showed signs of soot), 8 were partially missing (3 showed signs of soot), and only 5 were intact. The epoxy closeout over these labels, generally up to 6"x1-1/4"x1/8-inch thick, is a debris concern. Action is presently being taken to correct this problem on future flights. Accessible labels will be removed from the 5th flight

FIGURE 13. RIGHT SRB AFT SKIRT EXTERIOR TPS

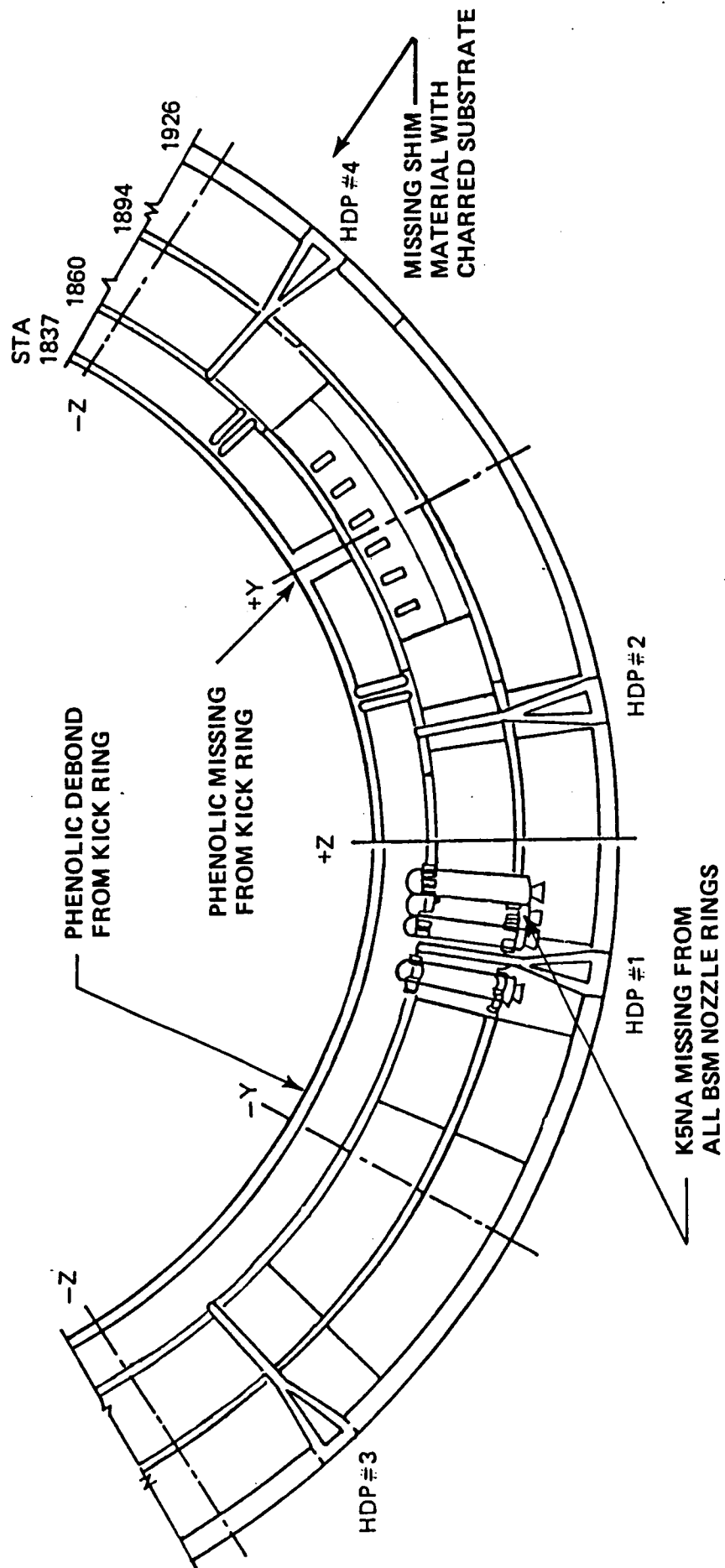
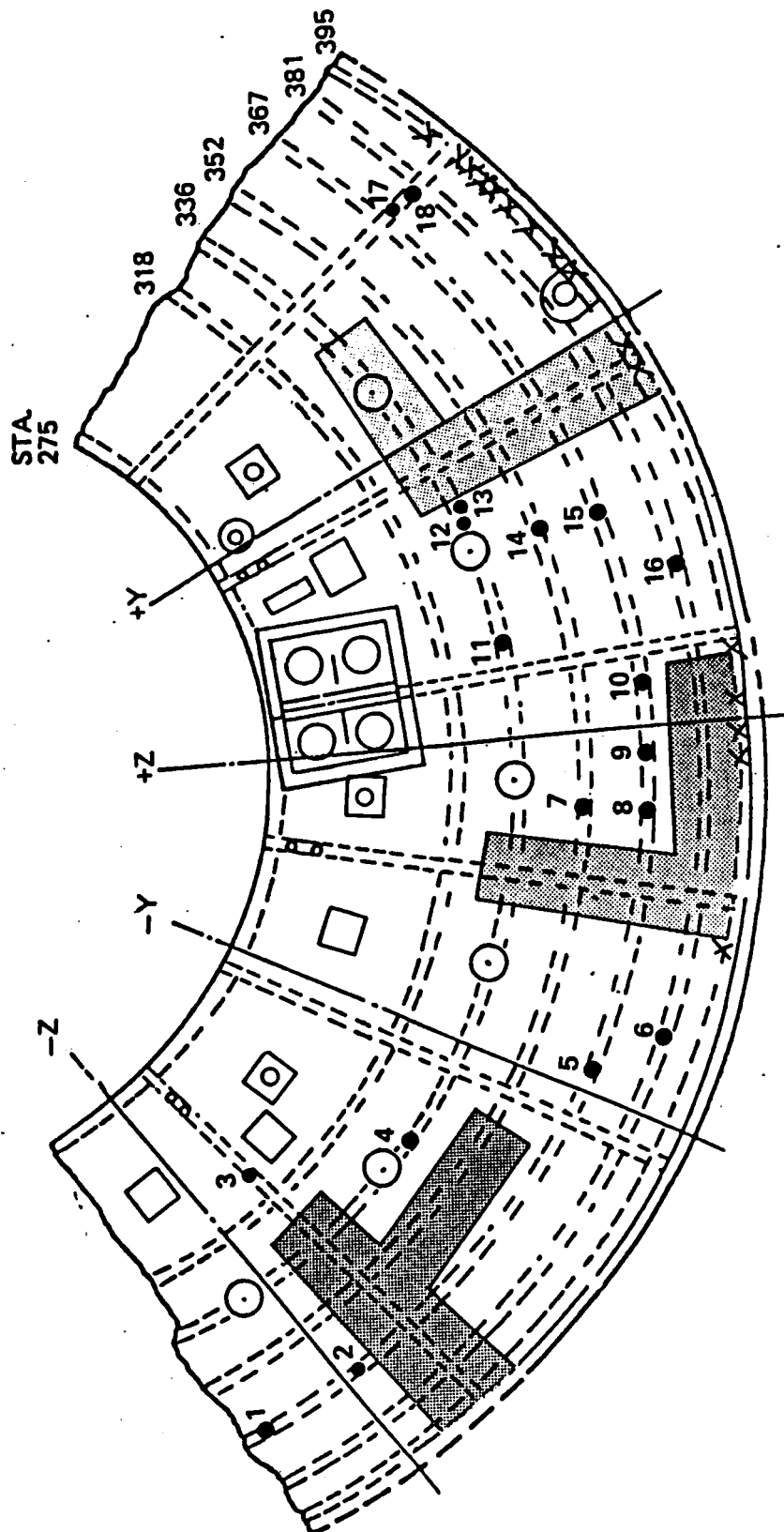


FIGURE 14. LEFT SRB FRUSTUM



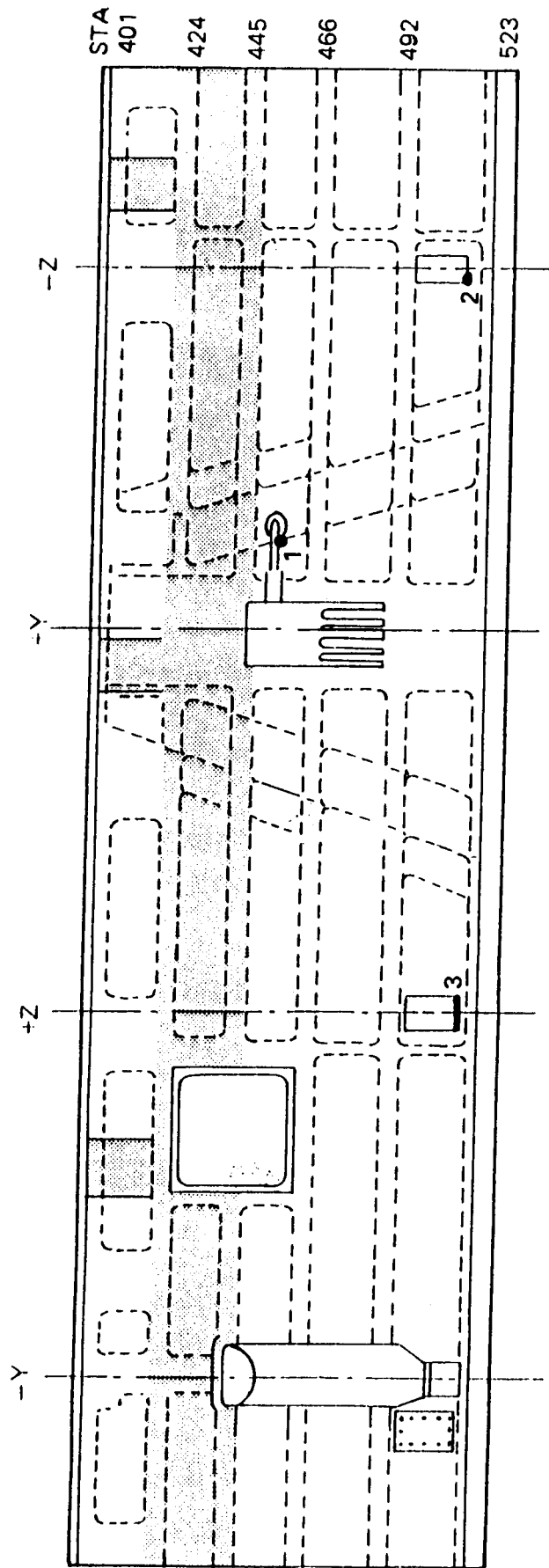
MISSING TPS

NONE

DEBONDS

TOTAL OF 104 RANDOM
DEBONDS OVER SEALANT
CAPS. AVG. SIZE 1½" DIA

FIGURE 15. LEFT SRB FWD SKIRT



TPS MISSING

- 1) 2" x 1" ABLATOR CORK IS SOOTED
- 2) 1" x 1/2" SLA 220 REMAINING MATERIAL IS SOOTED

DEBONDS

- 3) RSS ANTENNA PHENOLIC PLATE DELAMINATED

set and replaced with stencils. All labels are to be removed from the 6th flight set and the GEI ID information stenciled on the case.

Stiffener rings, instafoam, and an IEA cover sustained water impact damage due to the loss of one main parachute and faster descent at splashdown. K5NA was cracked on all 3 stiffener rings (270 degree location). Three bolts on the ETA ring cover were sheared. Some instafoam aft of the IEA was missing prior to water impact. Separation of the aft ET/SRB struts was nominal.

The kick ring exhibited torn and missing phenolic material at the 270 degree location. K5NA was missing from all four BSM nozzles. Instafoam was missing prior to water impact from the HDP #8 and the HPU exhaust line areas. The acreage areas of ablator on the aft skirt were generally in good condition with the typical 'popcorning'. The TVC system was virtually undamaged. Pieces of Epon shim were missing from posts #7 and #8 due to water impact (Figure 16).

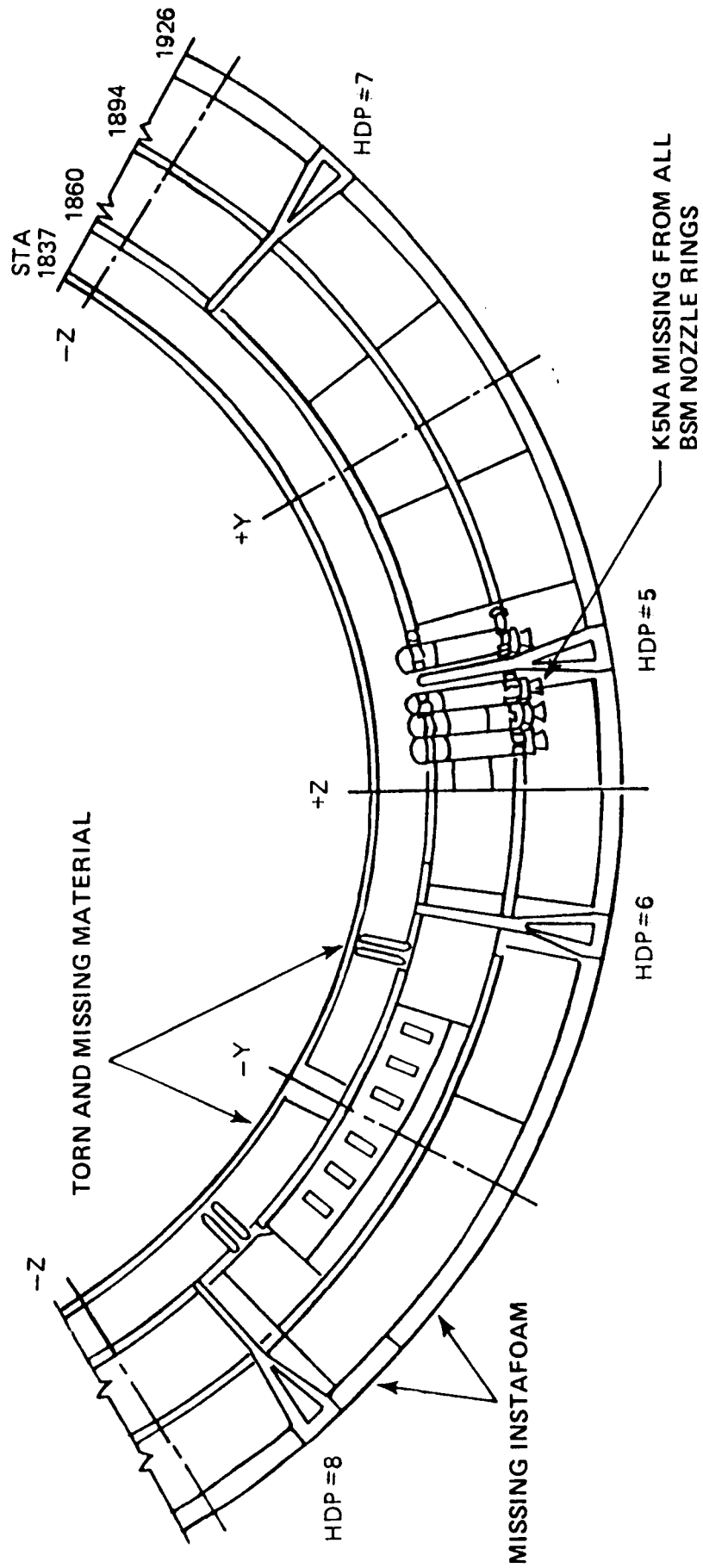
9.3 RECOVERED SRB DISASSEMBLY FINDINGS

The recovered SRB's are in much better condition than the last flight with no aft skirt structural damage and no evidence of fire. The LH SRB #2 main parachute failed to inflate and the booster impacted the water at higher than normal velocity. Cause of the failure has not been determined after examining the recovered hardware. The onboard film camera showed the deployment and failure, but no evidence was found that the parachute impacted the frustum structure during deployment. The higher than normal splashdown velocity is the probable cause for the damage to the three LH SRB stiffener rings and the broken nozzle snubber ring.

Twenty to twenty-five gallons of water entered the LH FWD skirt. Decontamination measures were taken to prevent corrosion of critical black boxes. Water entry into the forward skirts is a continuing unsolved design problem.

The joint protection system (JPS) closeouts were not a debris problem and the concern for cork debonding was partially alleviated by the rework and vent hole drilling. A crack developed in the cork on the RH FWD joint 30 degree location over the trunnion and allowed the void to vent rather than blow out. This location had not been drilled since it was outside of the debris-concern area. Several other void areas, which were not detected during the installation process, were discovered during removal of the JPS. Voids and debonds in the JPS remain a debris concern.

FIGURE 16. LEFT SRB AFT SKIRT EXTERIOR TPS

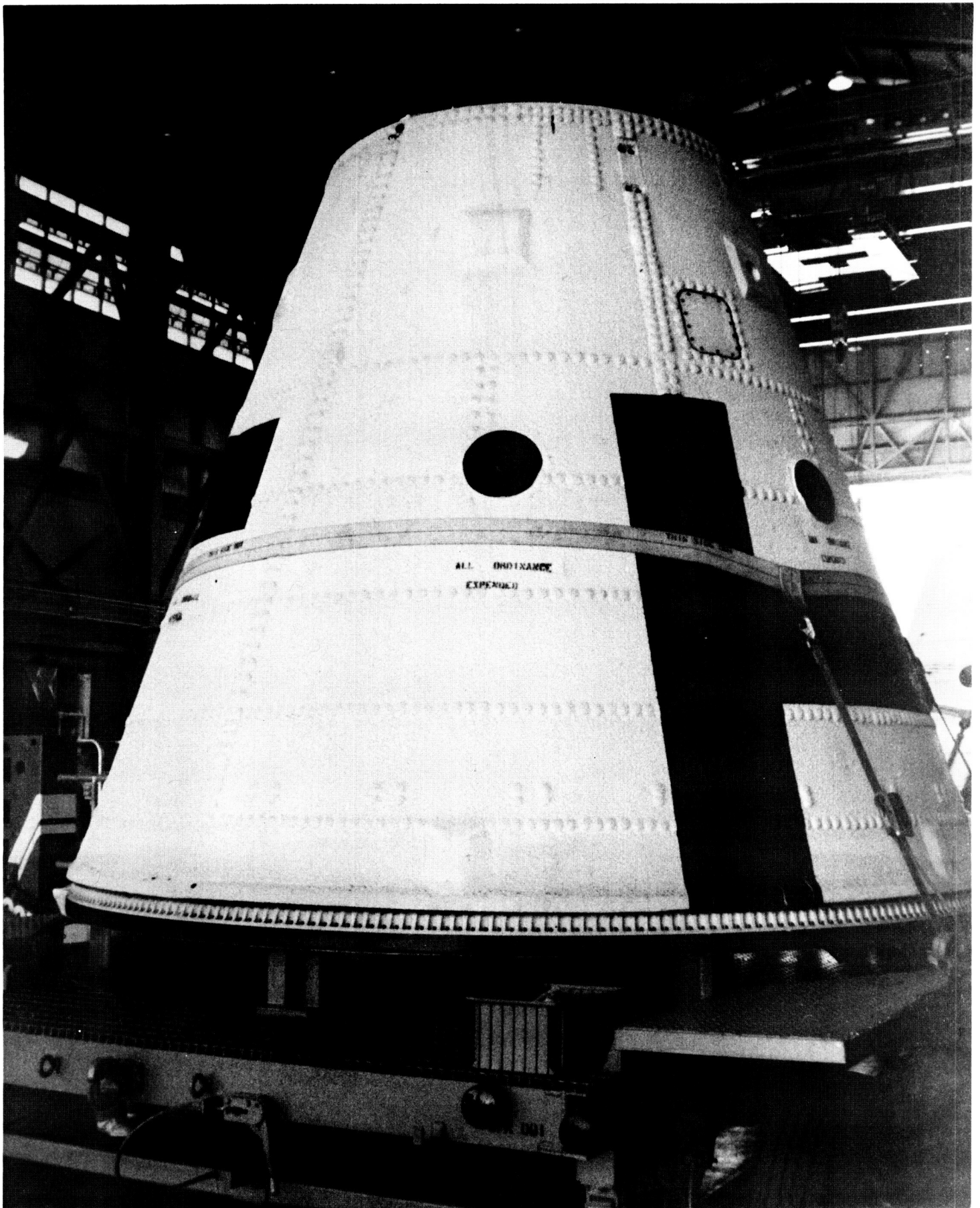


Three factory joint EPDM weather seals showed aft edge debond regions on the LH Aft segment allowing sea water intrusion into the joint. No evidence of sooting was found under these debonds. This failure is a corrosion concern.

The holddown post debris container plug devices did not work as well as the last flight. Although the plungers operated properly in holddown post #4 and 8, part of a booster cartridge was lost from HDP #1. Major parts of both booster cartridges, detonators, and most of the frangible nut debris was missing from HDP #2 and the plunger was sitting on a nut half. One booster cartridge, detonator, and one large piece of nut debris was lost from HDP #3. A 1/8-inch frangible nut piece was obstructing the plunger of HDP #5, but not before most of the booster cartridges/detonators, and 2 large pieces of nut debris escaped the debris container. Although HDP #6 was not missing any debris fragments, the plunger was sitting on a 3/16-inch nut fragment. HDP #7 lost most of a booster cartridge/detonator and minor nut debris. The #7 plunger was obstructed by a frangible nut fragment.

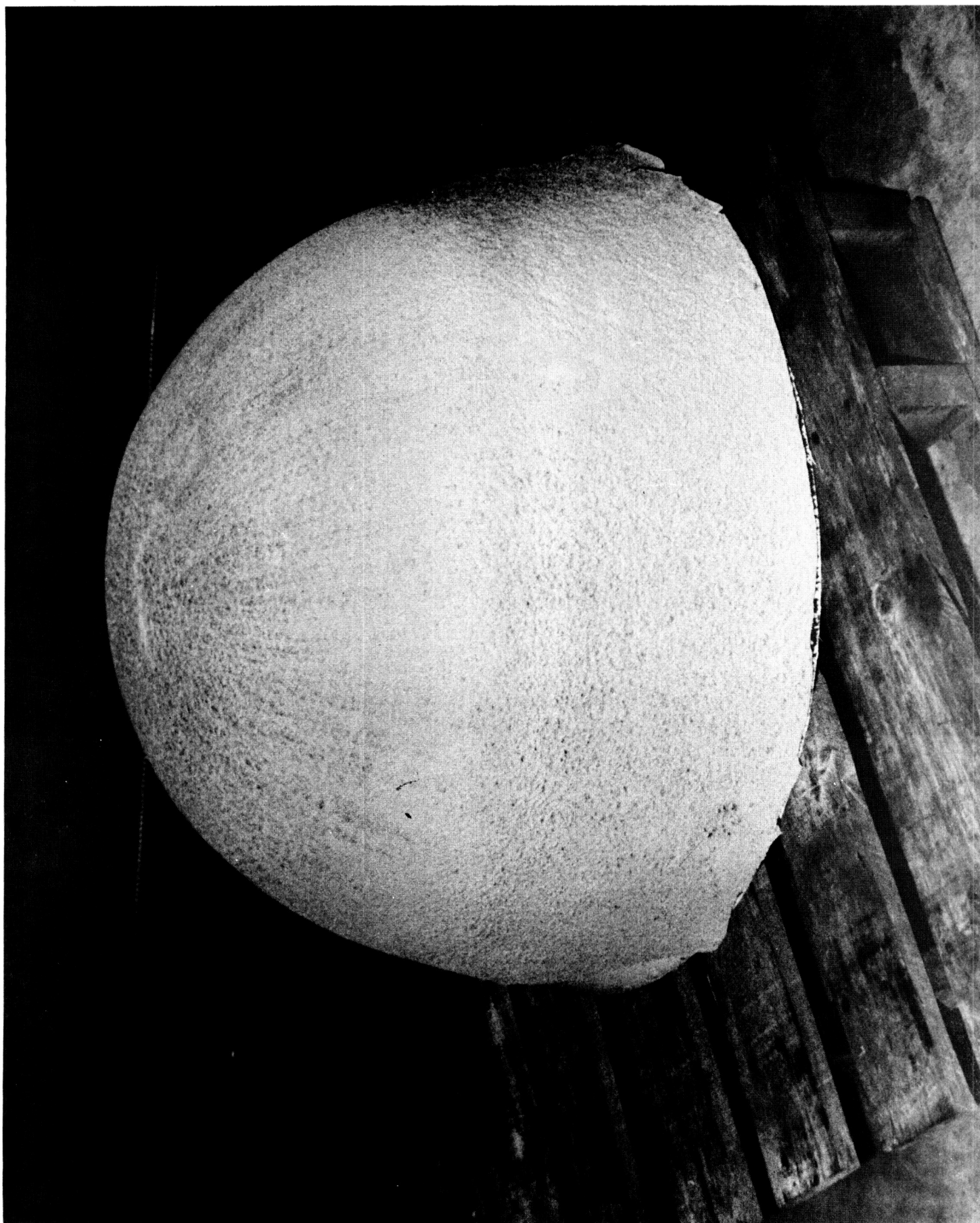
The LH SRB nozzle snubber attach ring sheared off and was wedged into the gap holding the flex bearing in a stretched condition. Nozzle snubbing has not occurred previously.

Observed SRB Post Launch Anomalies are listed in Section 12.0.

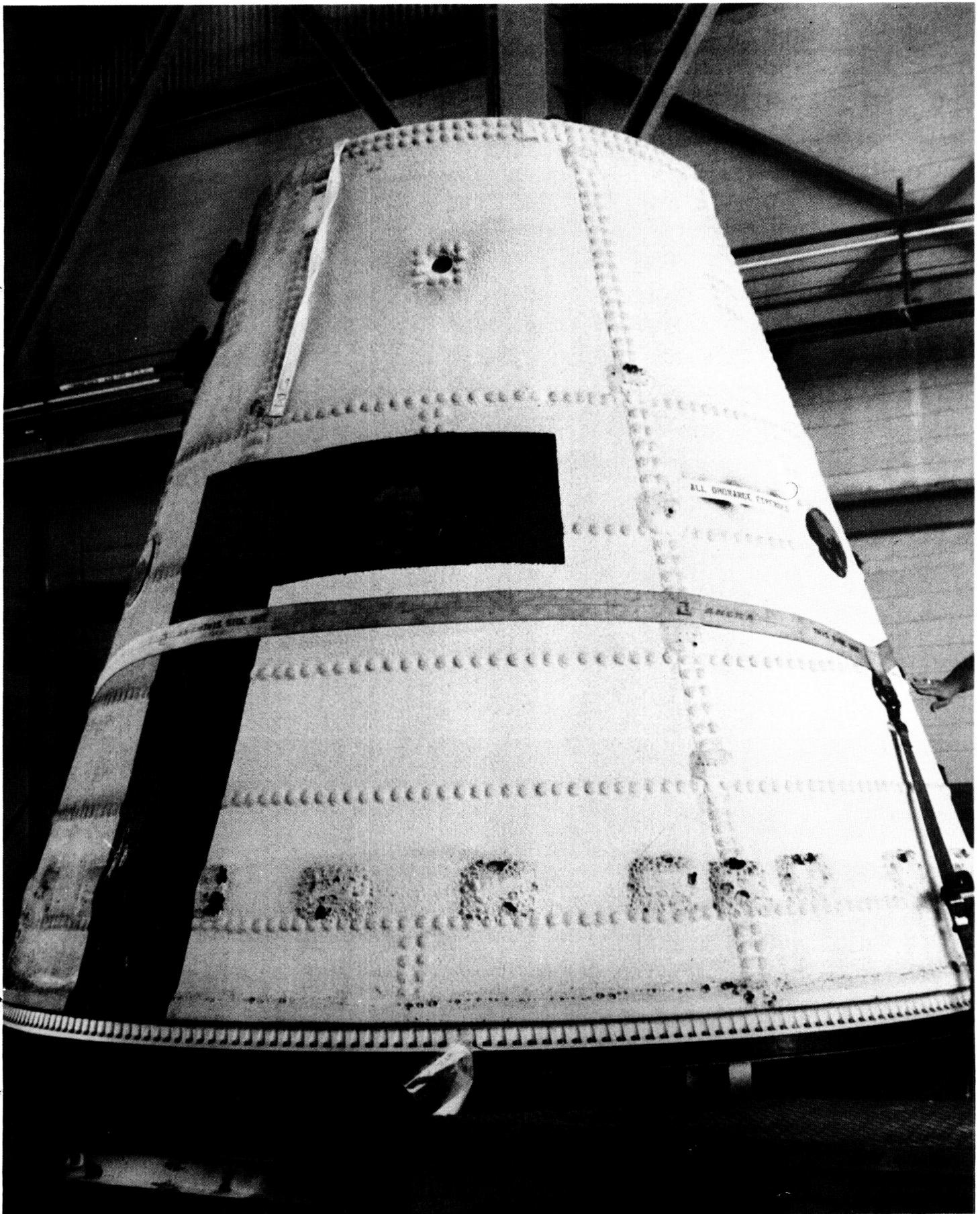


LH SRB FRUSTUM EXHIBITING NO MISSING TPS
AND MINIMAL HYPALON PAINT BLISTERING
145

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~~COLOR PHOTOGRAPH~~



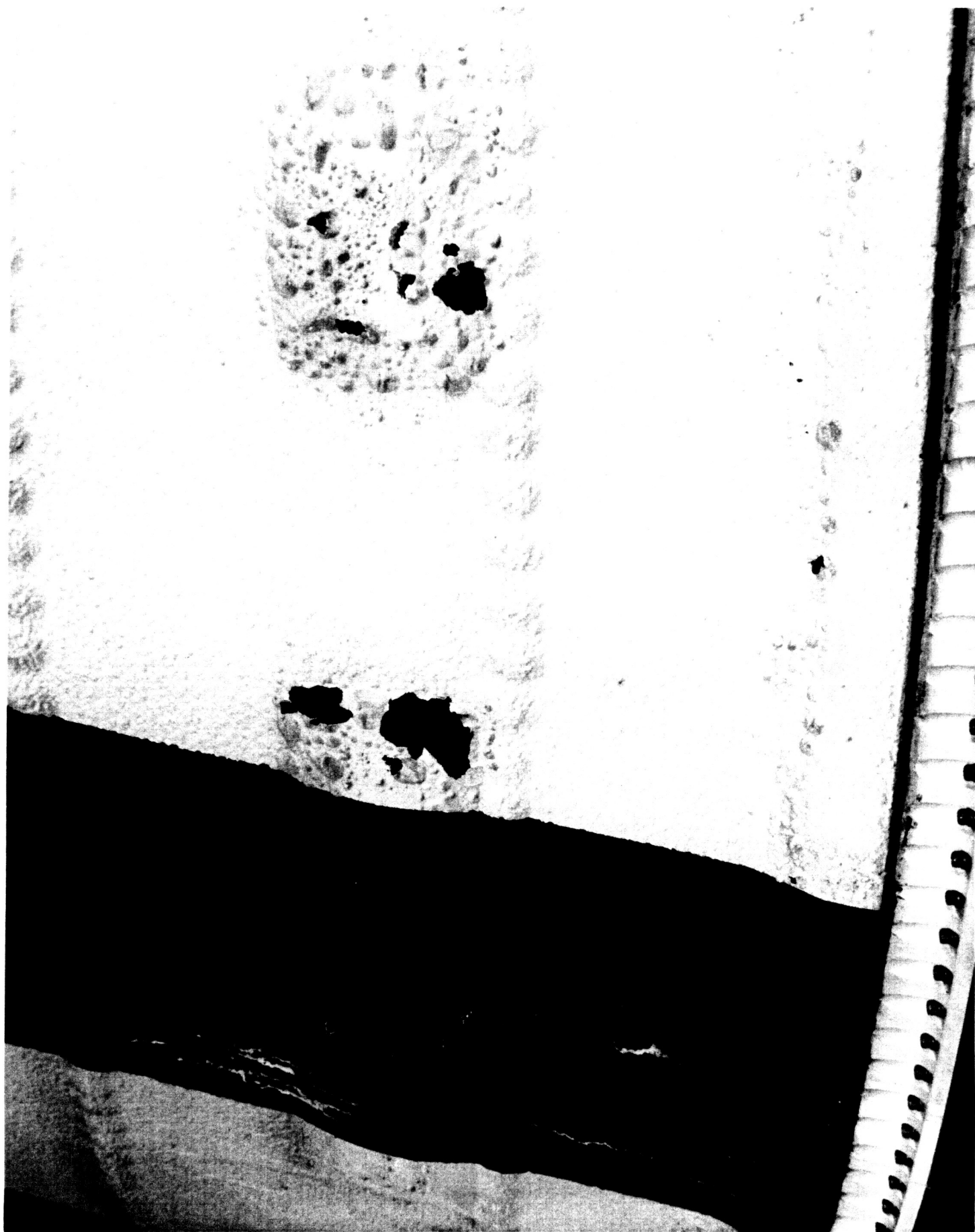
RH SRB NOSECAP DOME SHOWING NO ABLATOR ADHESION PROBLEMS



RH SRB FRUSTUM EXHIBITS NO MISSING TPS, BUT
PROBLEM WITH HYPALON PAINT BLISTERING CONTINUES

147

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HYPALON PAINT BLISTERS TYPICALLY HAVE
MSA-2 ABLATOR ATTACHED TO THE PAINT

148

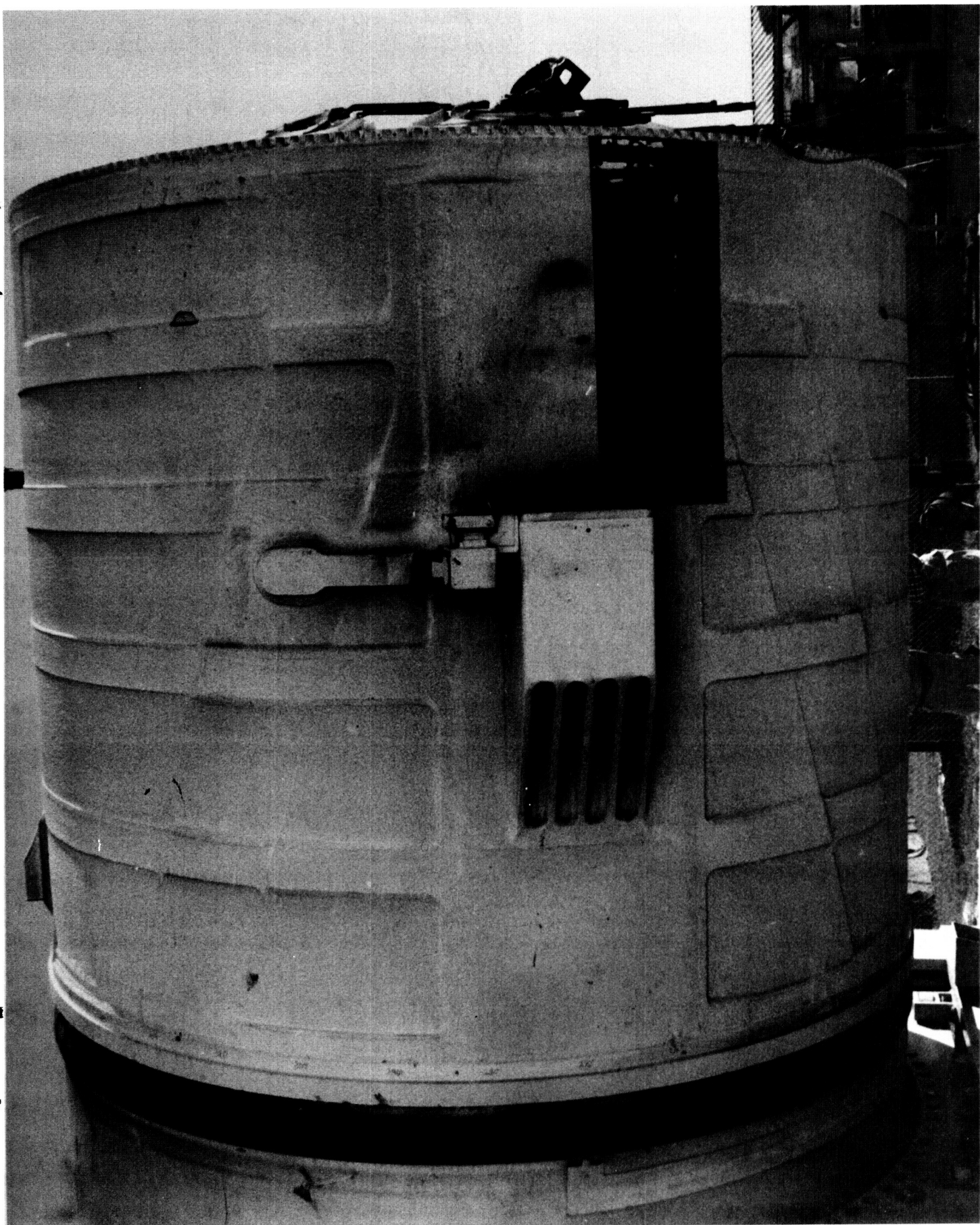
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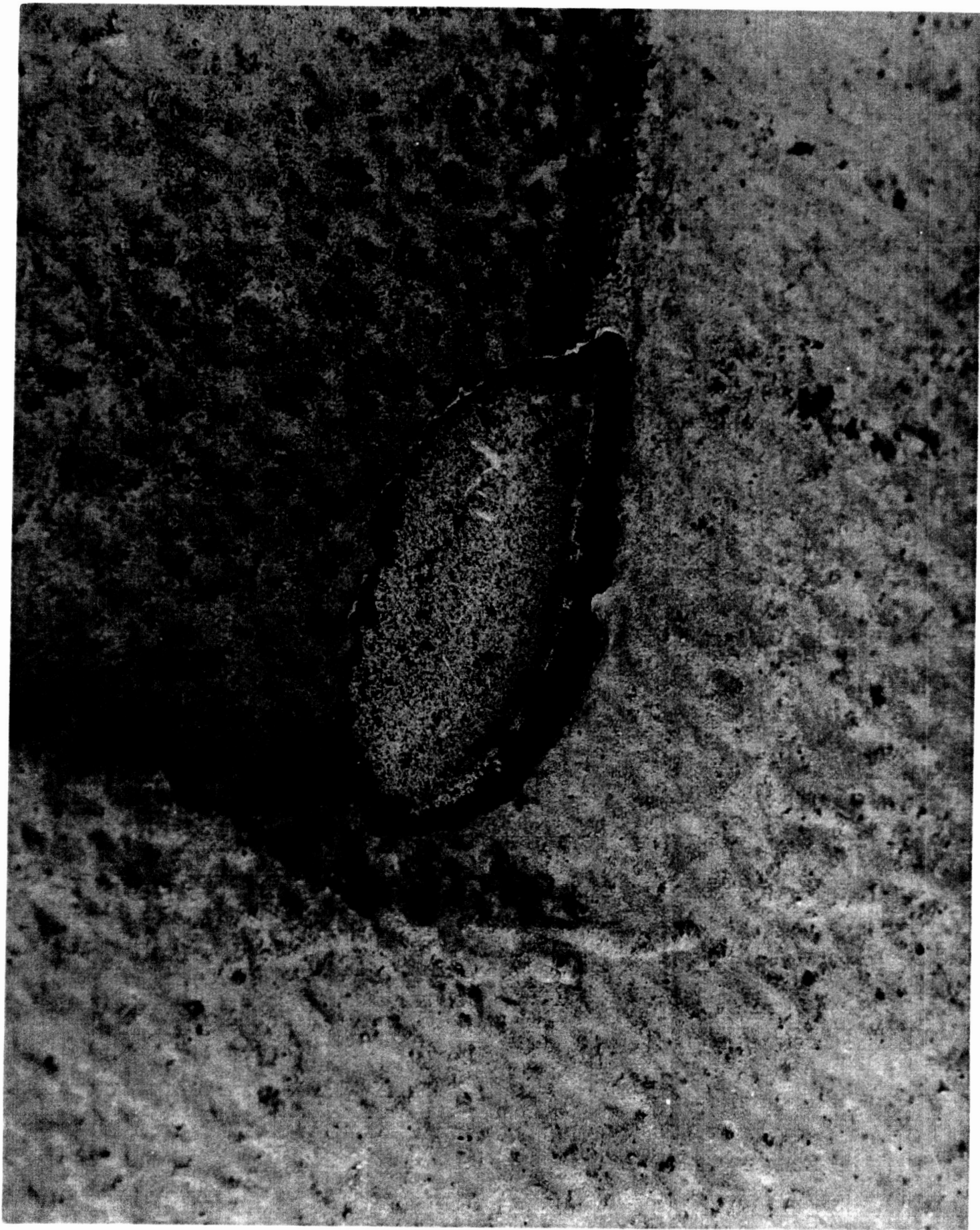
HYPALON PAINT BLISTERS WITH MSA-2 ABLATOR ATTACHED
WERE AS LARGE AS FIVE INCHES IN DIAMETER



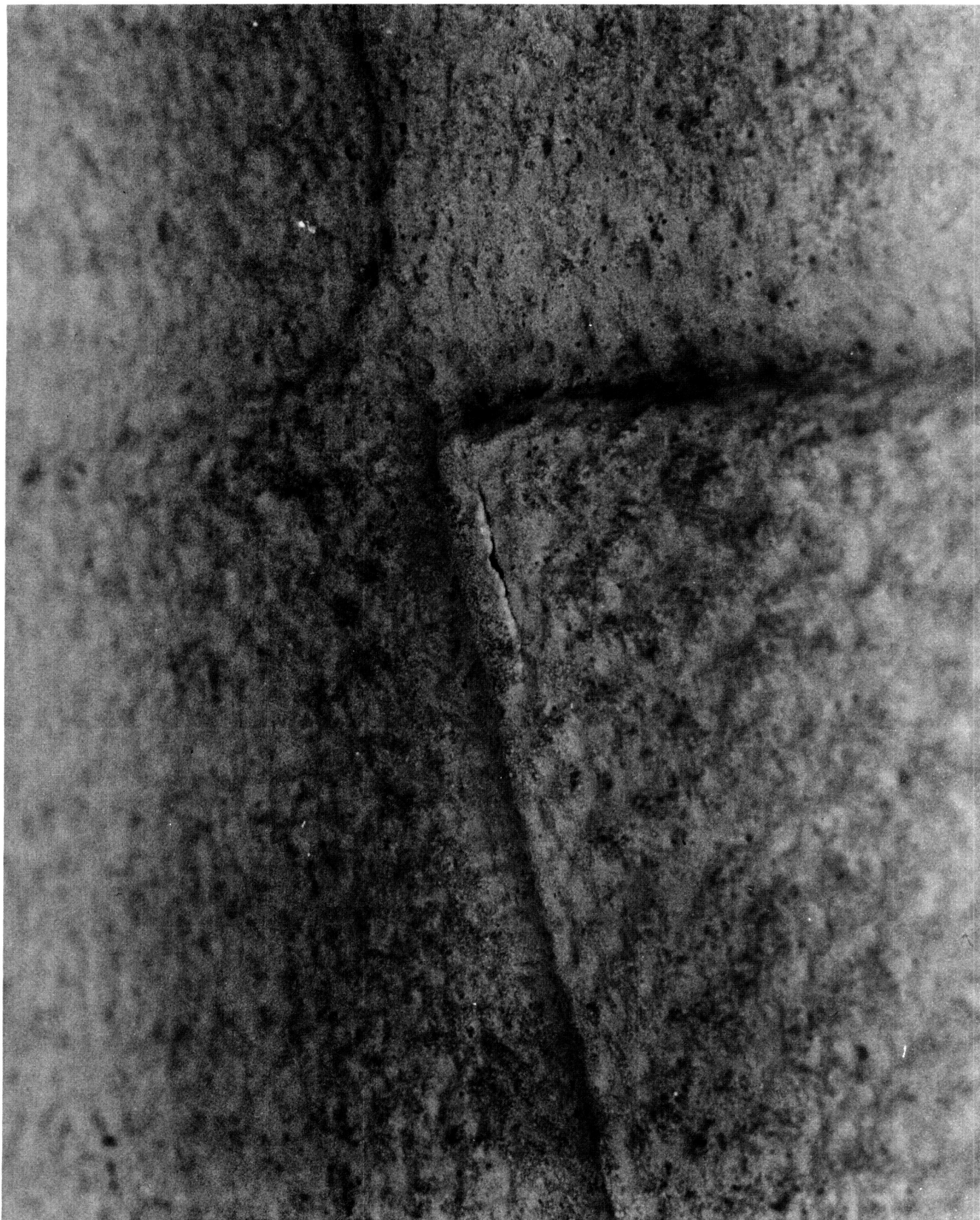
RH SRB FORWARD SKIRT EXHIBITING MINIMAL TPS DAMAGE

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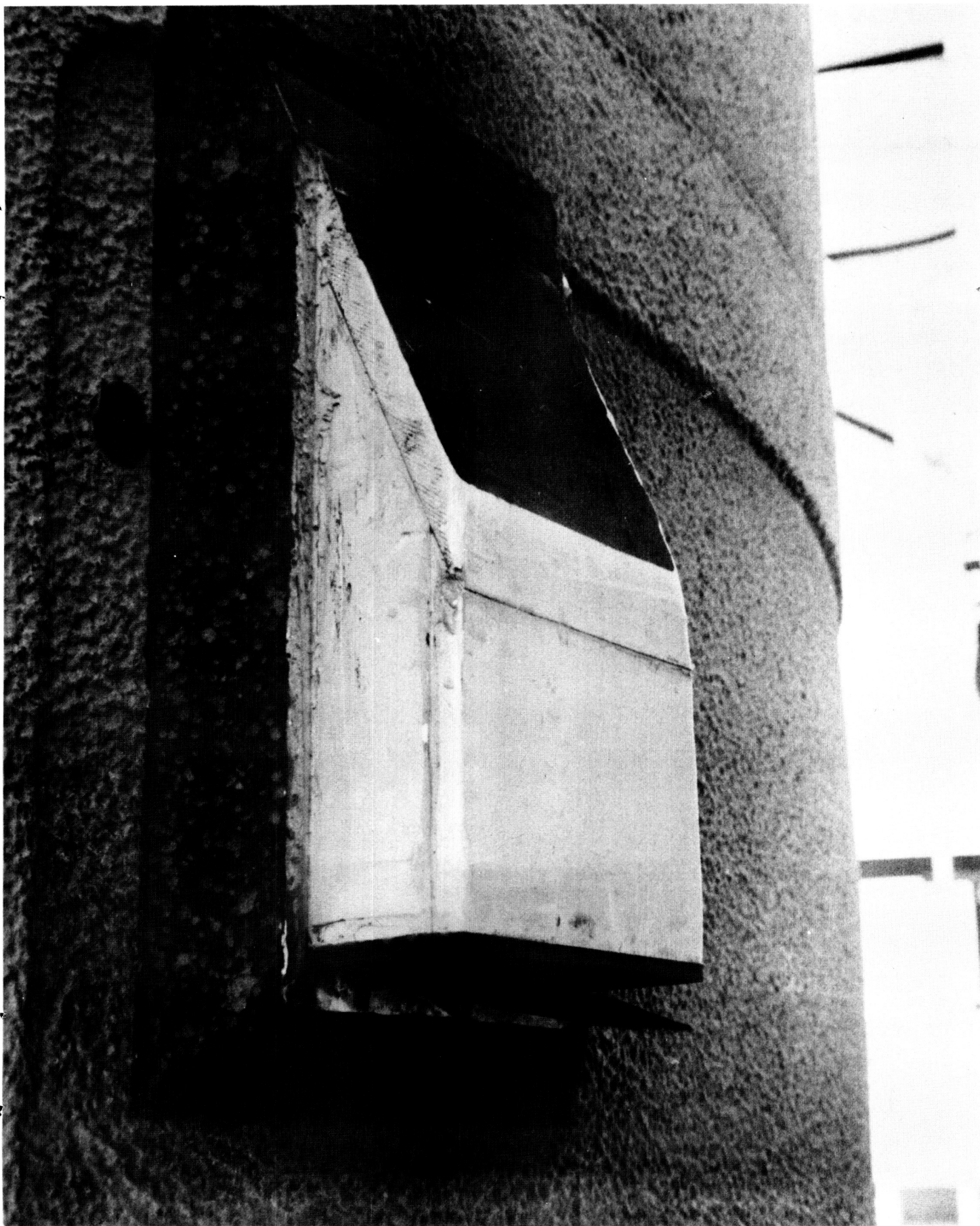
BLACK AND WHITE PHOTOGRAPH



FOUR INCH DIVOT ON RH SRB FORWARD SKIRT



TWO AND ONE HALF INCH CRACK ON RH SRB FORWARD SKIRT ABLATOR

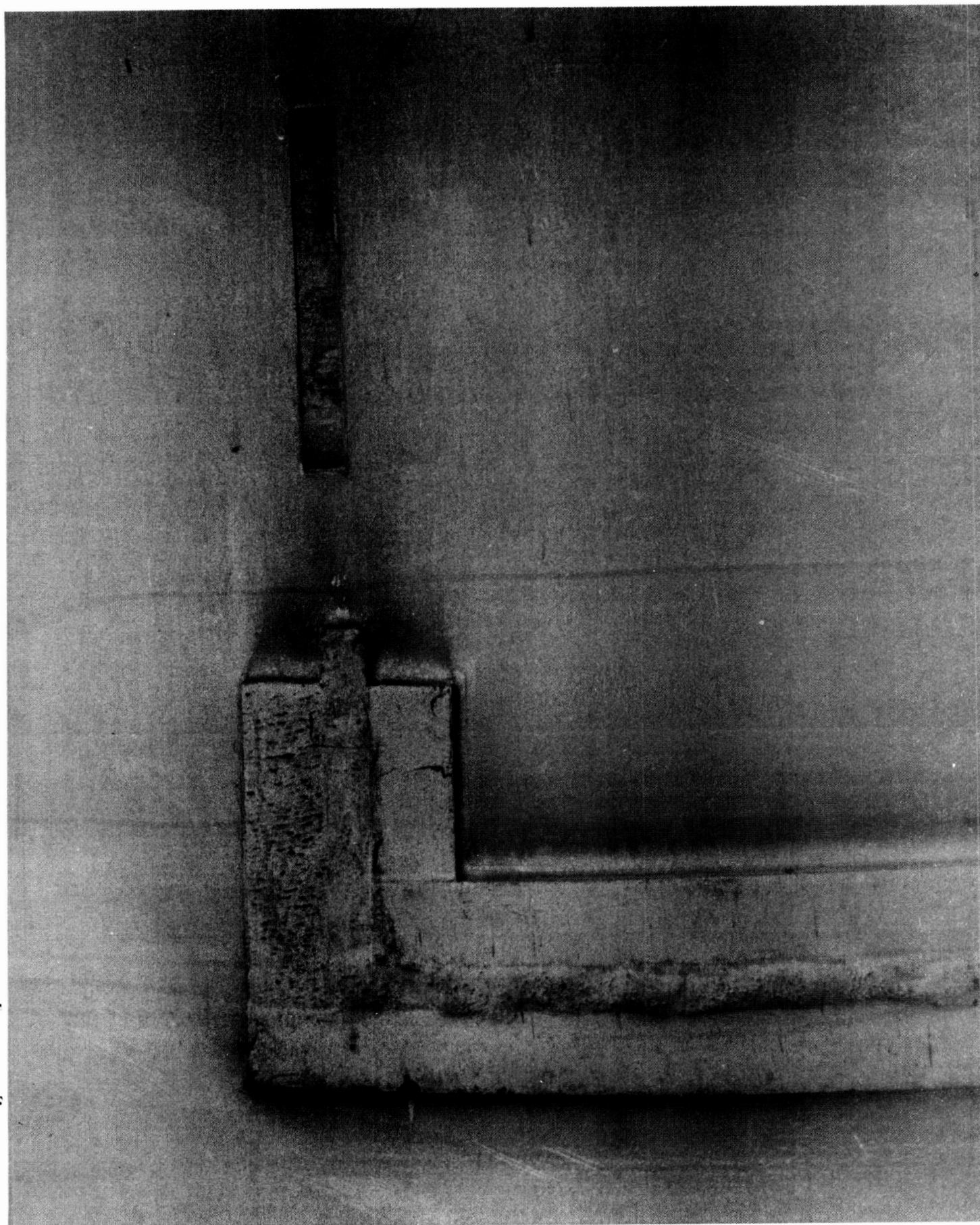


DELAMINATED RSS ANTENNA PHENOLIC PLATE ON LH SRB FORWARD SKIRT



TWO INCH BY ONE INCH DIVOT ON AFT SIDE
OF LH SRB FORWARD SKIRT BANJO FITTING
154

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COLOR PHOTOGRAPH

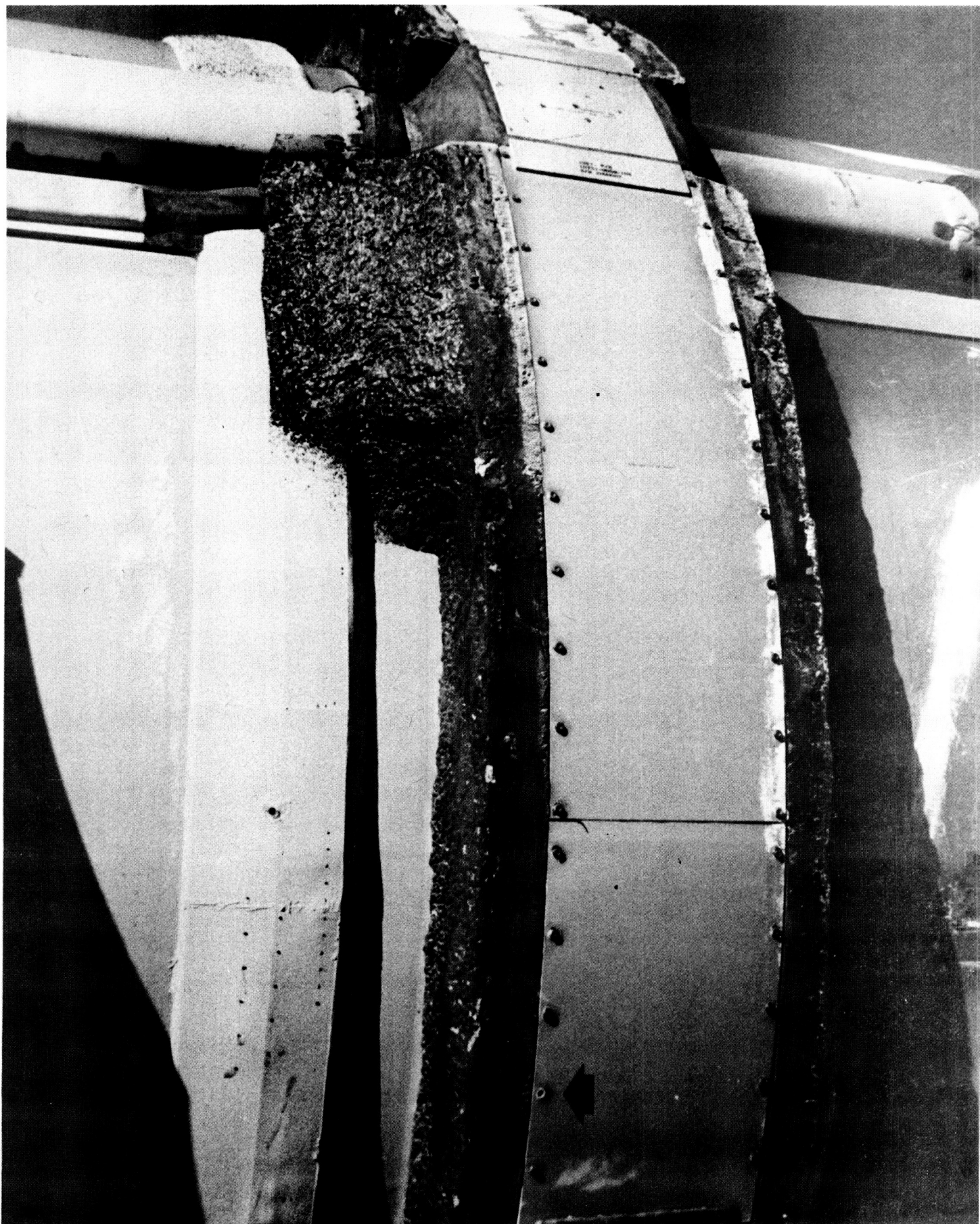


MISSING (TYPICAL) EPOXY COVERED GEI ID LABEL FROM SRB CASE

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155

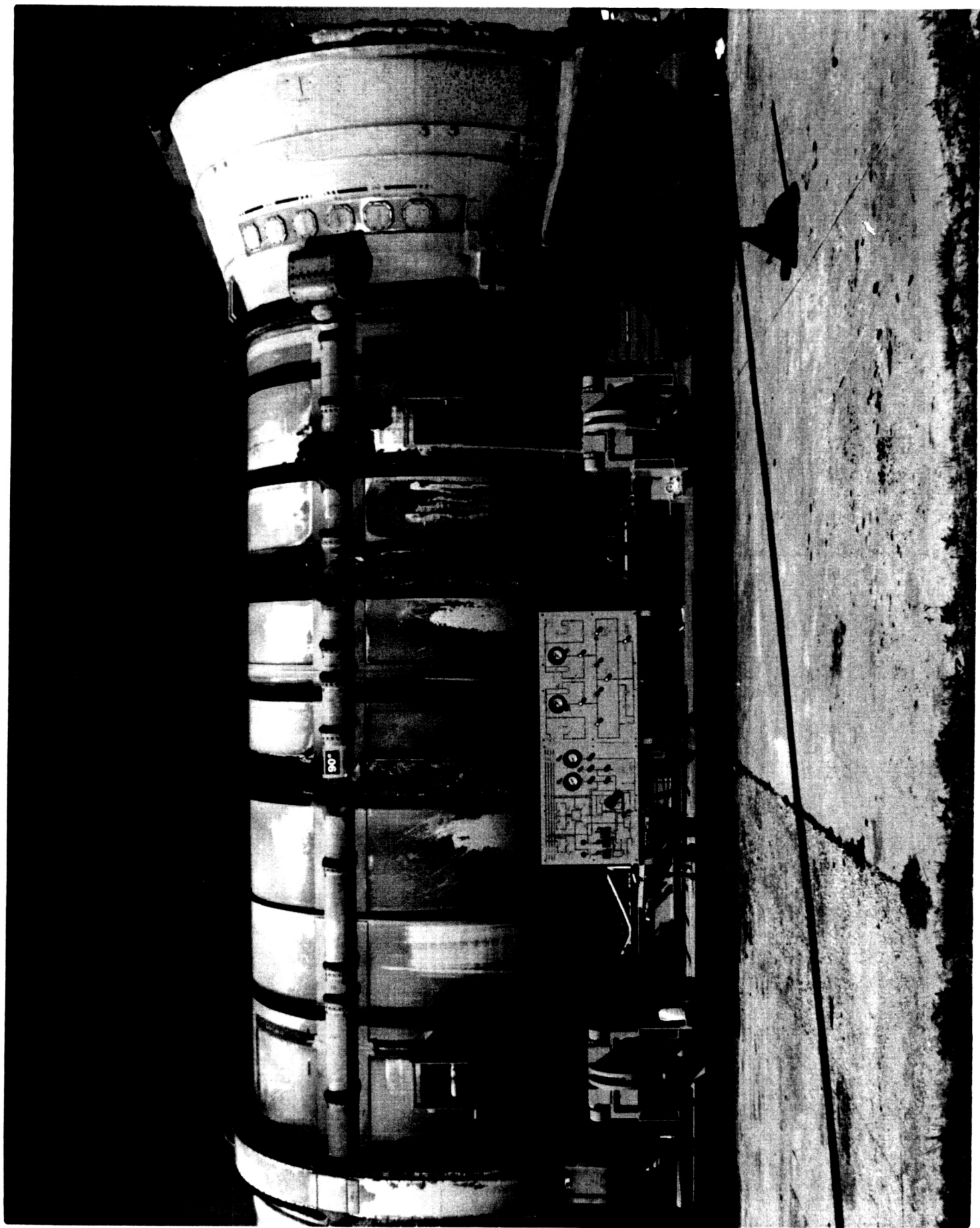
BLACK AND WHITE PHOTOGRAPH



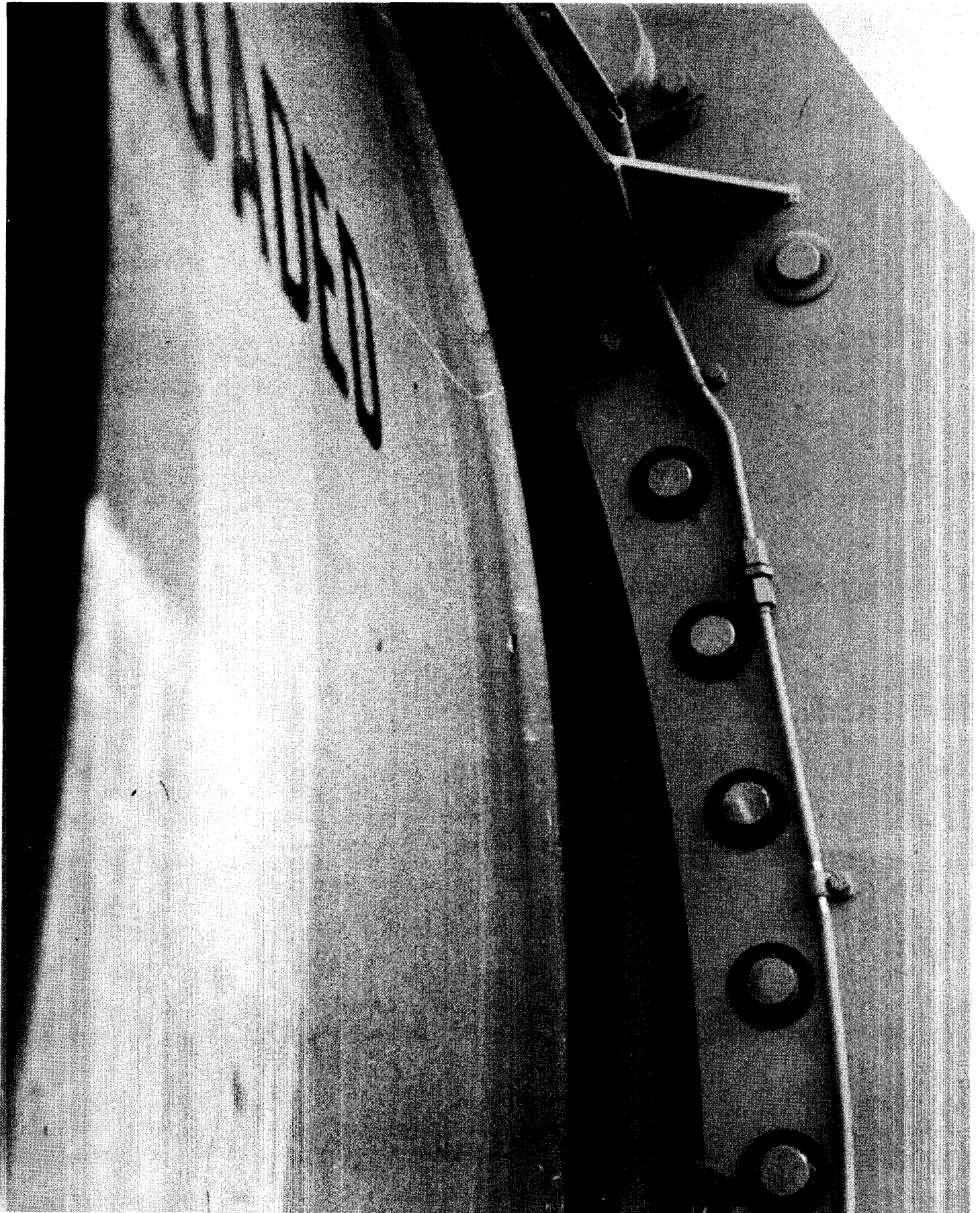
MISSING BOLT FROM ETA RING COVER



DELAMINATED PHENOLIC MATERIAL ON KICK RING



OVERALL VIEW OF RH AFT BOOSTER



AFT EDGE DEBOND OF LH AFT FACTORY JOINT EPDM WEATHER SEAL



LOSS OF K5NA FROM BSM NOZZLES



LOSS OF AFT SKIRT INSTAFOAM FROM AFT RING BETWEEN
HDP #8 AND HPU EXHAUST PIPE PRIOR TO SPLASHDOWN



LOSS OF HOLDDOWN POST SHIM MATERIAL PRIOR TO SPLASHDOWN

10.0 ORBITER POST LANDING DEBRIS ASSESSMENT

A detailed post landing inspection of OV-104 was conducted 8-9 May 1989 at Ames-Dryden (EAFB) on the concrete Runway 22 and in the Mate/Demate Device (MDD) to identify debris impacts, damage caused, and if possible, debris sources. The Orbiter sustained a total of 151 hits, of which 56 had a major dimension of one inch or greater. This total does not include the approximately 50 hits on the base heatshield.

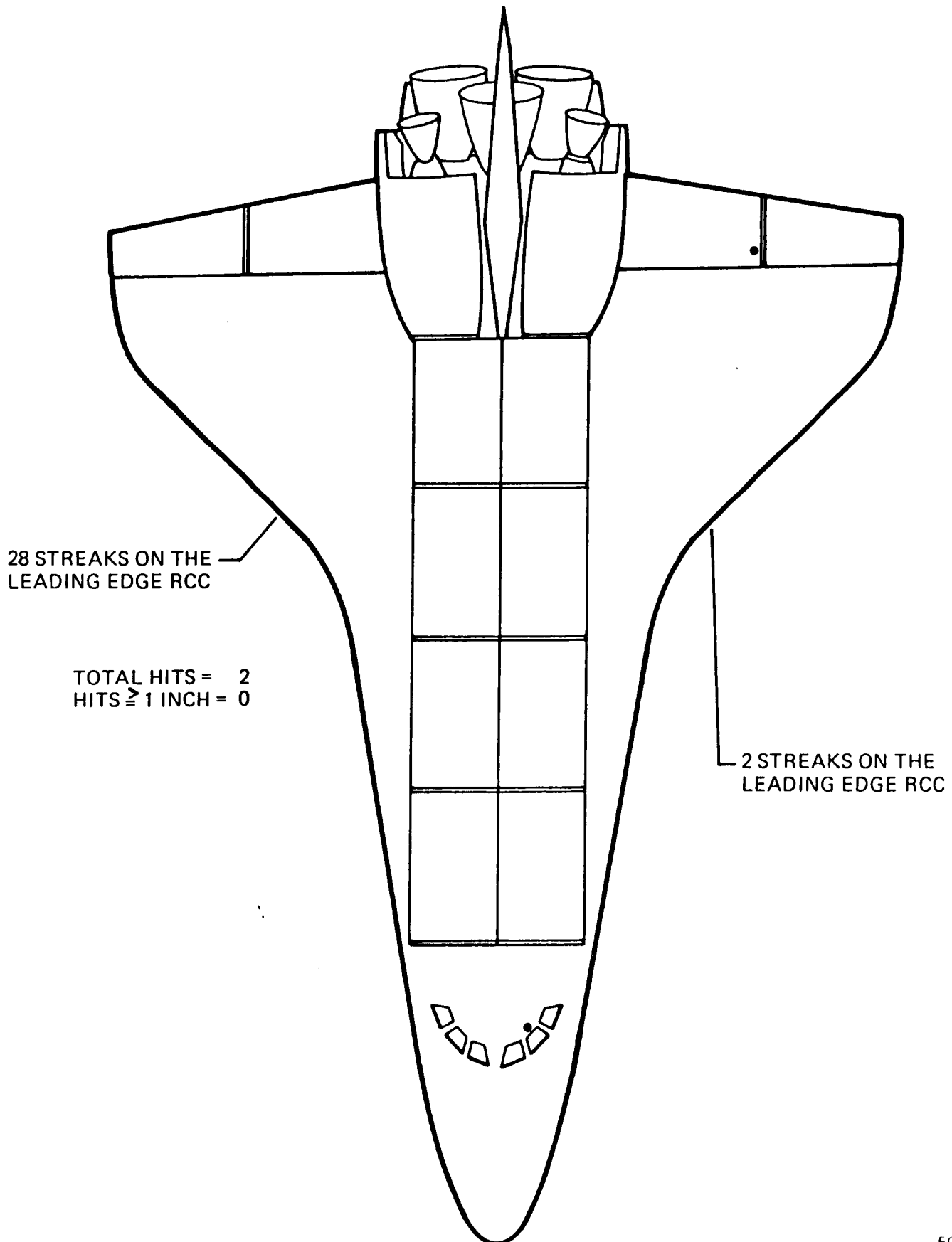
The Orbiter lower surface had a total of 134 hits, with 52 greater than 1 inch. The upper surface sustained a total of 17 hits, with 4 greater than 1 inch. The majority of the lower surface damage was sustained during landing and appears to be from the rubber debris from the LH MLG tires. With this damage excluded from the total count, the lower surface had a total of 64 hits, with 7 greater than 1 inch. Based on these numbers, comparison to statistics from 22 previous missions of similar configuration (excluding missions STS-24, 25, 26, 26R, and 27R which had damage from known debris sources), the total number of hits on the lower surface is lower than normal. Also, based on the severity of damage as indicated by surface area and depth, this flight is considered to be better than average. Figures 17-21 summarize the damage assessment for STS-30R.

The primary (17L) and secondary (23) runways were inspected and debris collected the day prior to landing. However, runway 22 was chosen just prior to touchdown to accomplish the crosswind landing DTO.

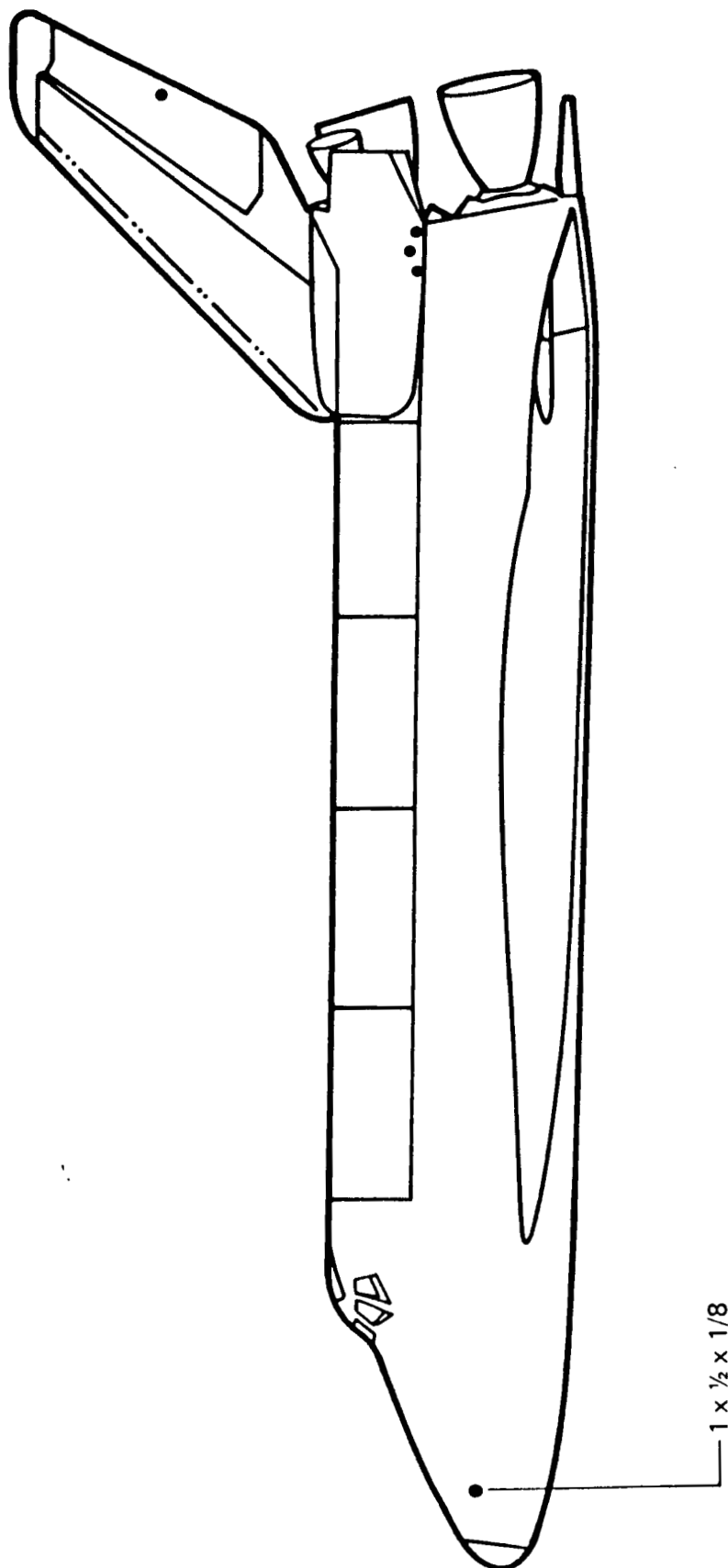
The post landing walkdown of Runway 22 was performed at approximately L+1 hour. Many pieces of rubber material were found along the south (left) edge of the runway. Representative samples were collected and submitted to the KSC Microchemical Analysis lab for comparison to the orbiter tire material. This comparative analysis, listed in Section 11, indicates that the specimens collected were identical in composition to orbiter tire material. Numerous nuts, bolts, other fasteners, and miscellaneous hardware were also found but are not considered to be from the orbiter. Flight hardware, such as tile pieces, gap fillers, and thermal barriers, usually found on the runway were not present for this mission.

The majority of the lower surface damage was concentrated aft of the LH main landing gear. This area had a total of 70 hits, with 45 greater than 1 inch and is attributed to rubber debris from the tires during rollout. The tires showed evidence of wear and material loss. The wires from the main landing gear strain gage system, which caused damage on STS-29R, were not debris sources for the STS-30R mission.

STS-30R DEBRIS DAMAGE LOCATIONS

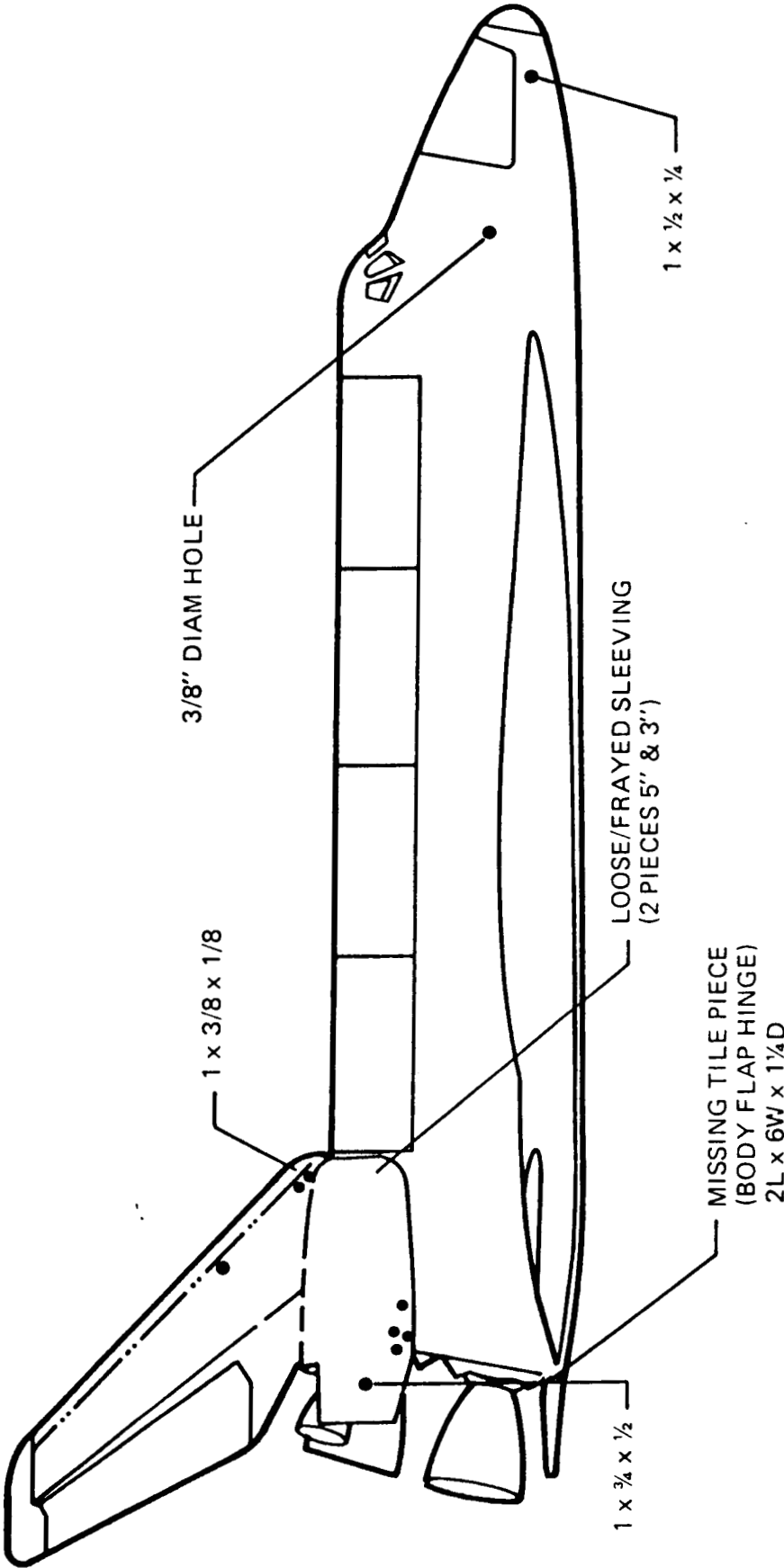


STS-30R
DEBRIS DAMAGE LOCATIONS



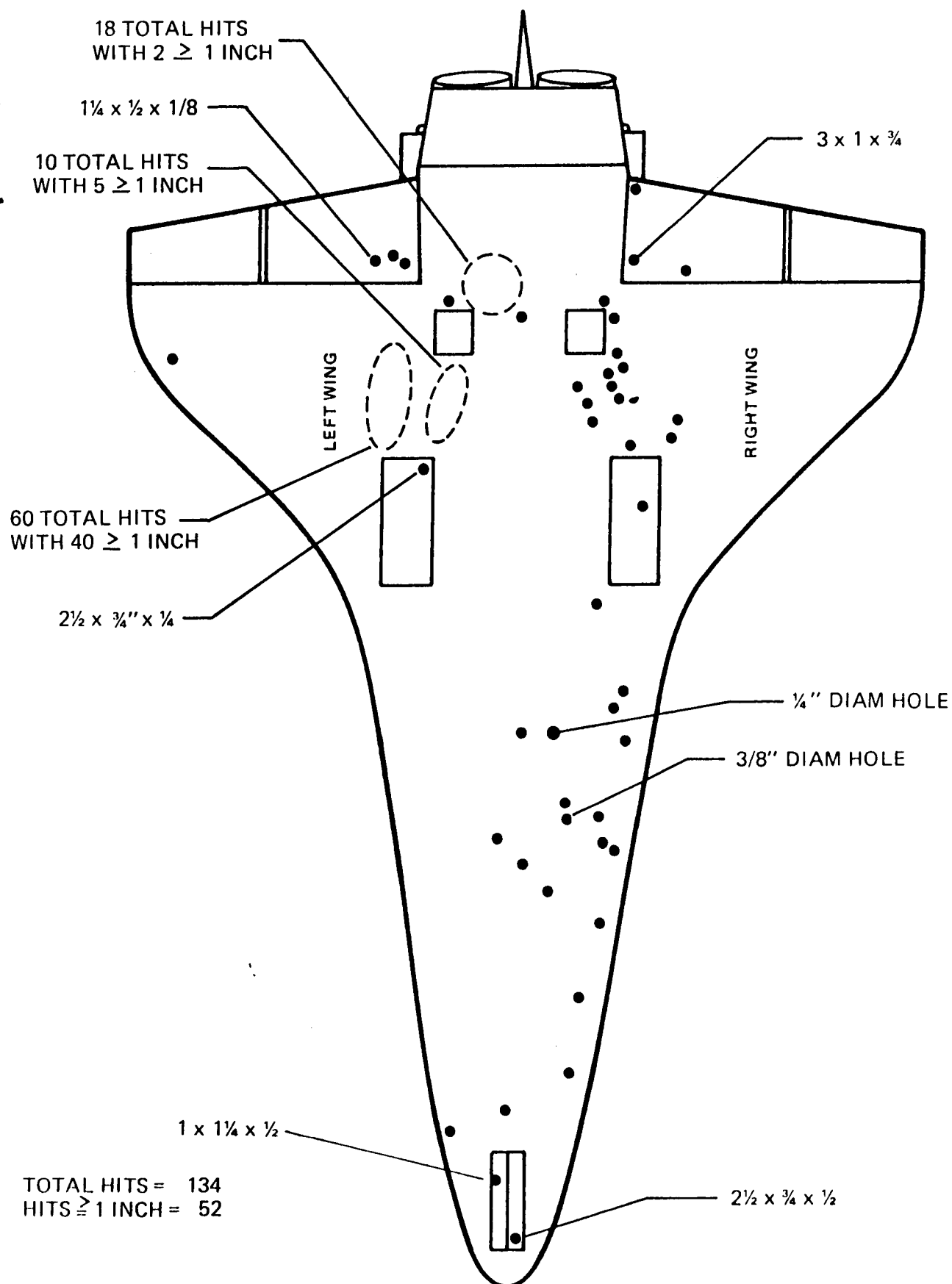
TOTAL HITS = 5
HITS \geq 1 INCH = 1

STS-30R
DEBRIS DAMAGE LOCATIONS

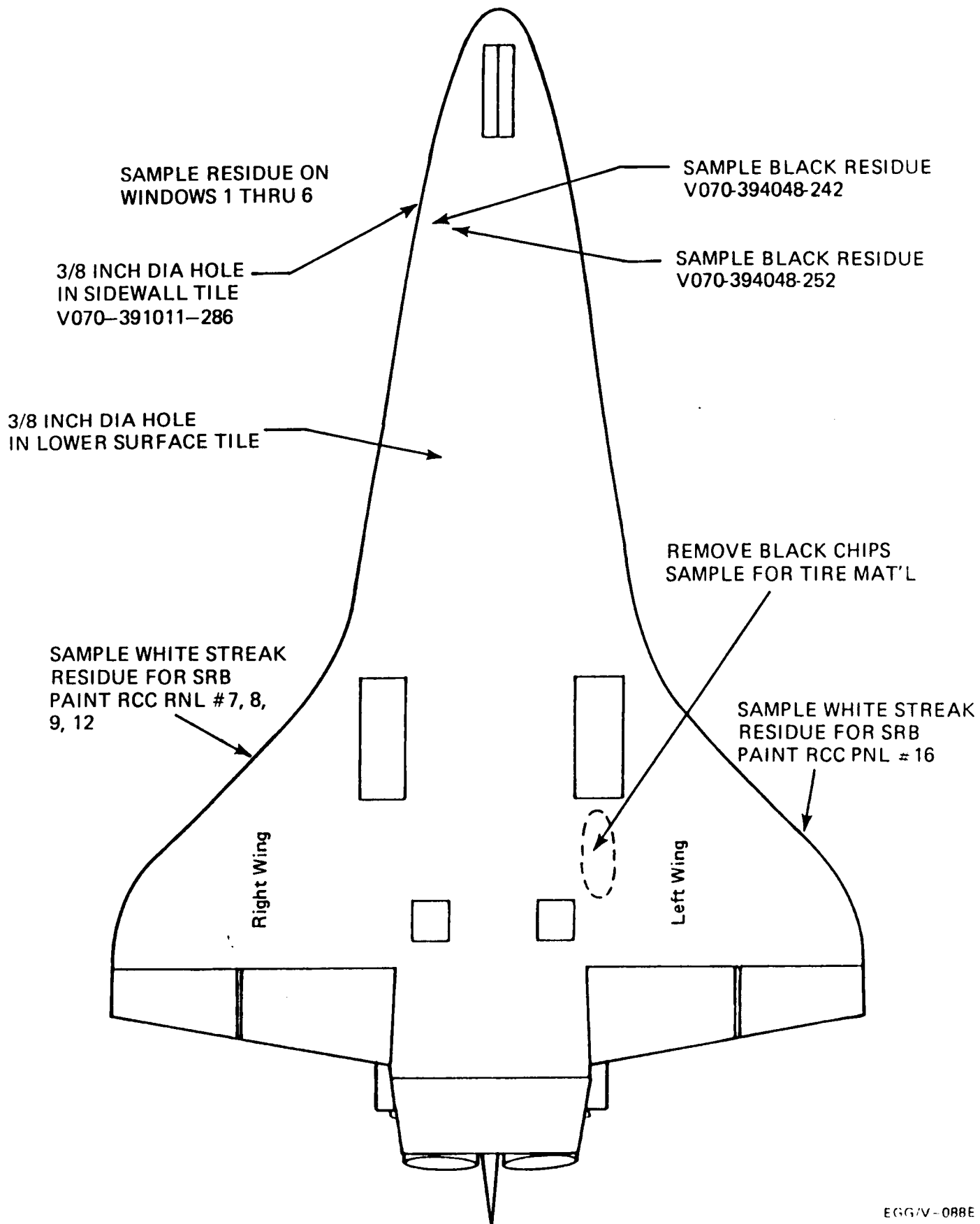


TOTAL HITS = 10
HITS ≥ 1 INCH = 3

STS-30R DEBRIS DAMAGE LOCATIONS



STS-30R DEBRIS SAMPLE LOCATIONS



An area aft of the ET/ORB hydrogen umbilical had 18 hits with 2 greater than 1 inch. These hits are probably caused by debris emanating from the umbilical area at ET/Orbiter separation. Similar patterns have been observed on previous flights.

Loose sleeving material on the forward area of the RH OMS pod caused damage to one white tile.

A 6"x3"x1" portion of one tile on the upper surface of the right hand aft fuselage area of the body flap hinge was missing. This tile anomaly was identified in the review of several launch films.

Damage to the base heat shield tiles was considerably less than average. The main engine closeout blankets were damaged on all three SSME's. The nozzle thermal blanket on SSME #1 was damaged and loose on the second ring from the exit. Several tile chips occurred on the aft RCS stingers, which were also identified in the launch film reviews.

White streaks were present on the wing leading edge RCC. There were two streaks on the left side and 28 on the right side. Samples of these streaks were taken for laboratory testing, but did not contain enough material for the analysis.

Orbiter windows 1 through 6 were hazed. Residual matter could be seen on windows 3 and 4. Laboratory analysis was performed at KSC on samples taken from all windows (Reference section 11.0 for results). Window #6 also had an impact hit 0.1017 inches in length, 0.0919 inches in width, and 0.0115 inches in depth, documented on PR-STR-4-05-1575. This window will be removed and returned to Rockwell-Downey for further impact site analysis.

A pyrotechnic retainer yoke fell from the ET/ORB LO2 umbilical to the runway surface when the ET doors were opened after rollout. This condition was documented on PR-PYR-4-05-0073.

No evidence was apparent in the forward and aft ET attach areas of a rough External Tank separation as reported by the flight crew.

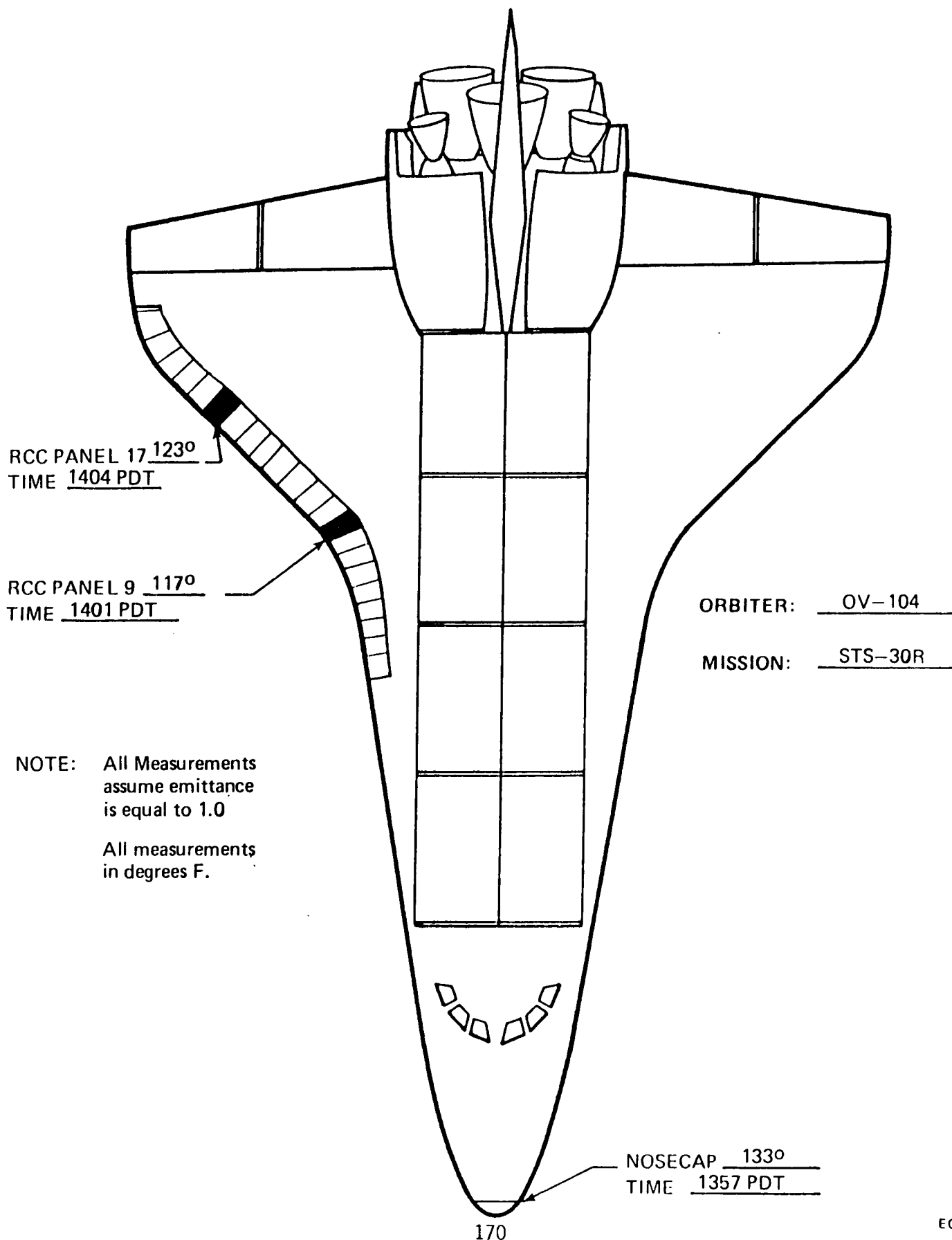
An infrared imaging system similar to the KSC Shuttle Thermal Imagers (STI) was used to record the thermal patterns of the Orbiter and estimate the kinetic surface temperatures of several areas. Due to the last minute runway change, which delayed convoy positioning, and other delays associated with hazardous gas indications during initial Orbiter safing, imaging of the orbiter touchdown/rollout and APU run was not possible.

Access to the Orbiter was attained at approximately L+1 hour and the RCC temperature values presented in Figure 22 were obtained with the infrared imaging system at the times noted.

Date: 9 MAY 1989

FIGURE 22

STS-30R TEMPERATURE MEASUREMENTS



All readings were obtained by positioning the imager perpendicular to the surface of interest and averaging the values over a small area for statistical validity. The recorded temperatures were greatly influenced by the high ambient temperature (100+ degrees F), time of day (early afternoon when solar heating is at a maximum), and strong head winds (increased convective cooling), which caused rapid temperature fluctuations on the RCC nosecap and leading edge panels.

In summary, the total number of Orbiter TPS debris hits after adjustment for suspected landing damage was less than average when compared to previous flights, as shown in the comparison chart (Figure 23). As adjusted, there were 11 hits greater than 1 inch in major dimension compared to the mission average of 30. Only 7 tiles will have to be removed and replaced. The distribution of hits on the Orbiter does not point to a single source for debris, but indicates a shedding of ice and TPS debris from random sources. The potential identification of sources of debris for mission STS-30R is based on the laboratory analysis of TPS damage sites, inspection of the recovered SRB components, and analysis of air/ground photography.

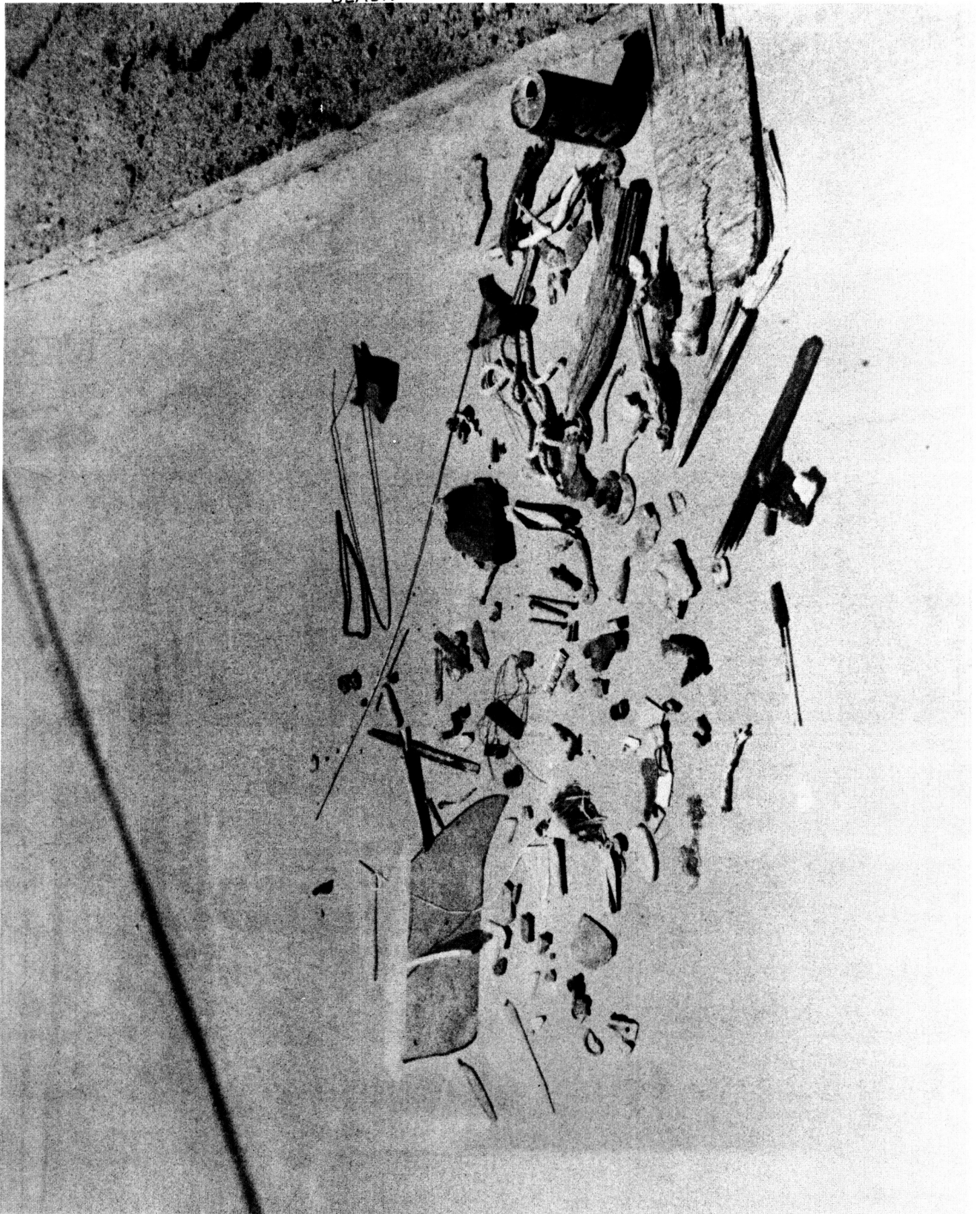
Observed Orbiter Post Launch Anomalies are listed in Section 12.

FIGURE 23. STS-30R DEBRIS DAMAGE ASSESSMENT SUMMARY

	<u>Hits > or = 1"</u>	<u>Total Hits</u>
Lower Surface	52	134
Upper Surface	0	2
Right Side	2	5
Left Side	1	2
Right OMS Pod	1	5
Left OMS Pod	0	3
TOTALS	56	151

COMPARISON TABLE

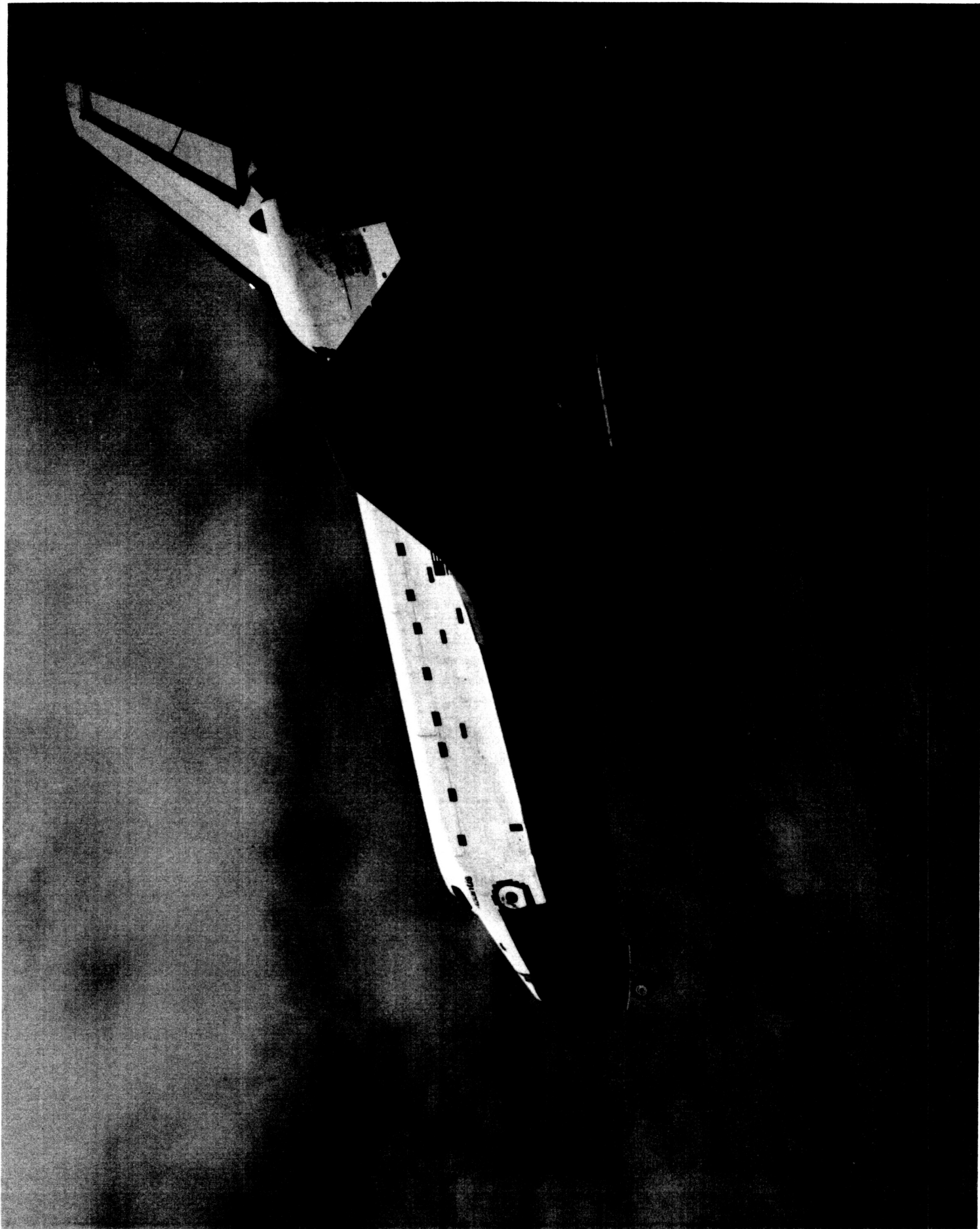
STS-6	36	120
STS-7	48	253
STS-8	7	56
STS-9 (41-A)	14	58
STS-11 (41-B)	34	63
STS-13 (41-C)	8	36
STS-14 (41-D)	30	111
STS-17 (41-G)	36	154
STS-19 (51-A)	20	87
STS-20 (51-C)	28	81
STS-23 (51-D)	46	152
STS-24 (51-B)	63	140
STS-25 (51-G)	144	315
STS-26 (51-F)	226	553
STS-27 (51-I)	33	141
STS-28 (51-J)	17	111
STS-30 (61-A)	34	183
STS-31 (61-B)	55	257
STS-32 (61-C)	39	193
STS-26R	55	411
STS-27R	298	707
STS-29R	23	132
STS-30R	56	151



REPRESENTATIVE SAMPLES OF DEBRIS COLLECTED
DURING PRE-LANDING RUNWAY INSPECTION



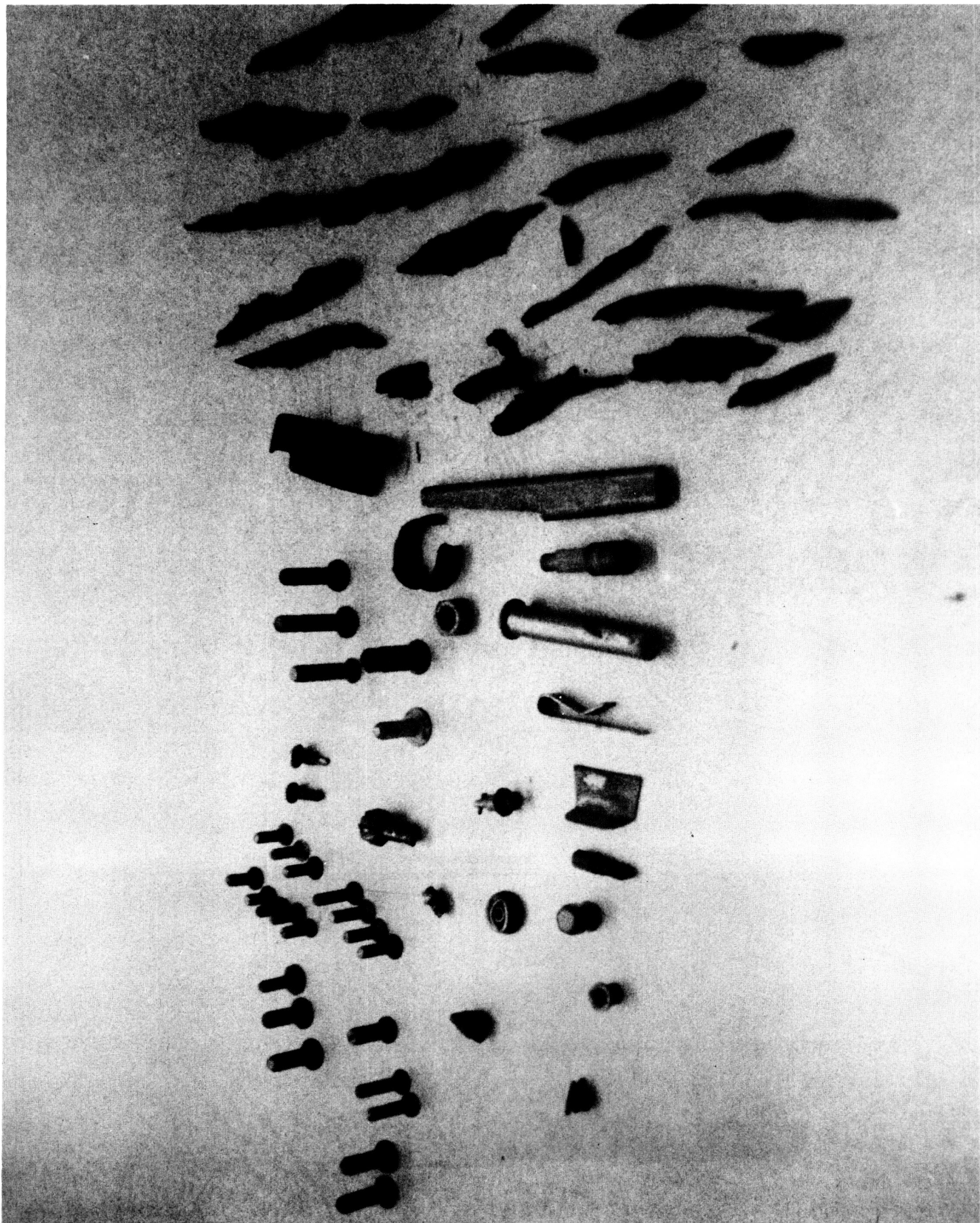
MINIMAL ORBITER TILE DAMAGE VISIBLE PRIOR TO LANDING



NO LANDING GEAR DOOR CORNER TILE PIECES LOST

175

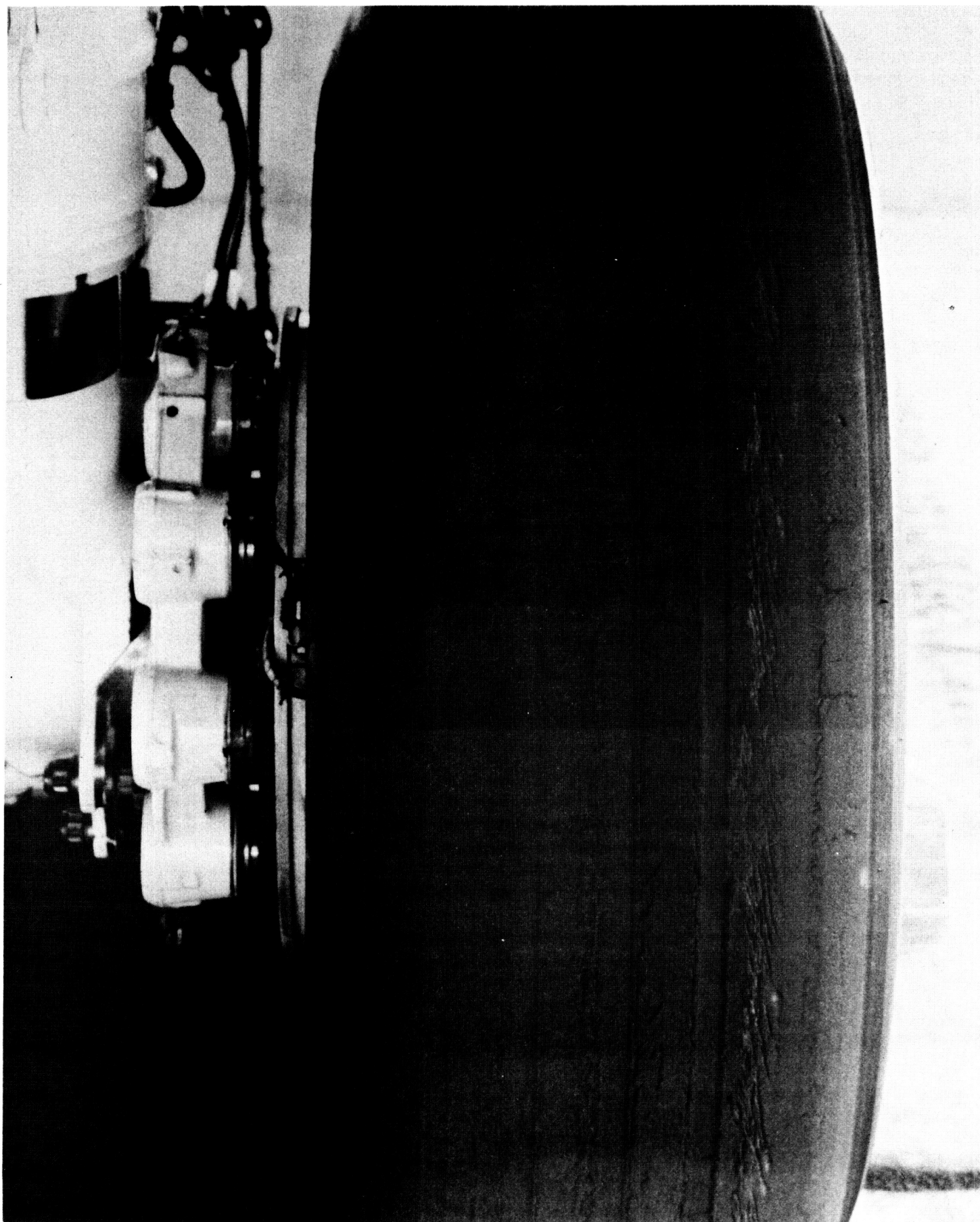
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DEBRIS COLLECTED DURING POST-LANDING RUNWAY INSPECTION

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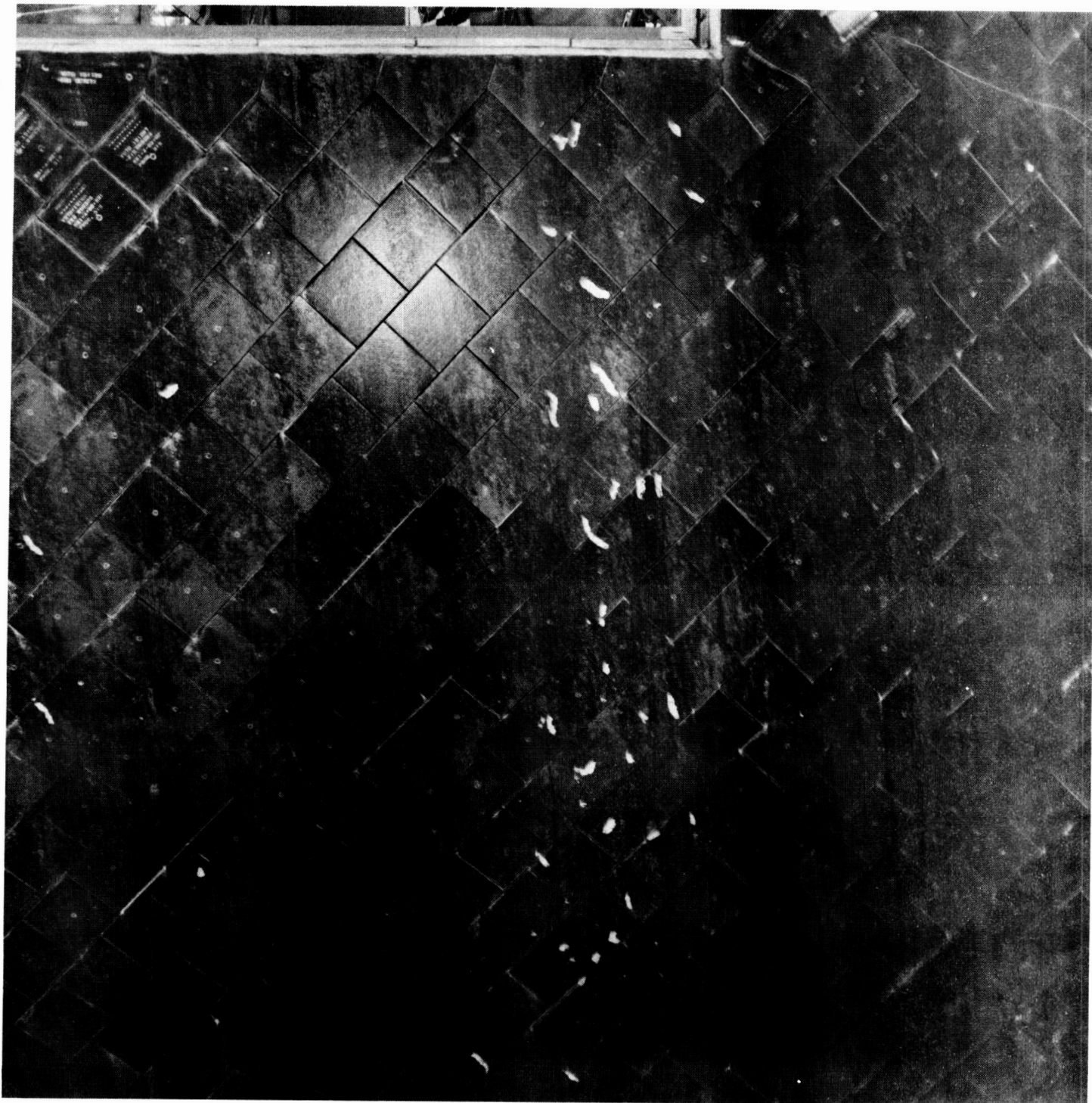
BLACK AND WHITE PHOTOGRAPH



LOSS OF TIRE MATERIAL FROM LH MAIN LANDING GEAR

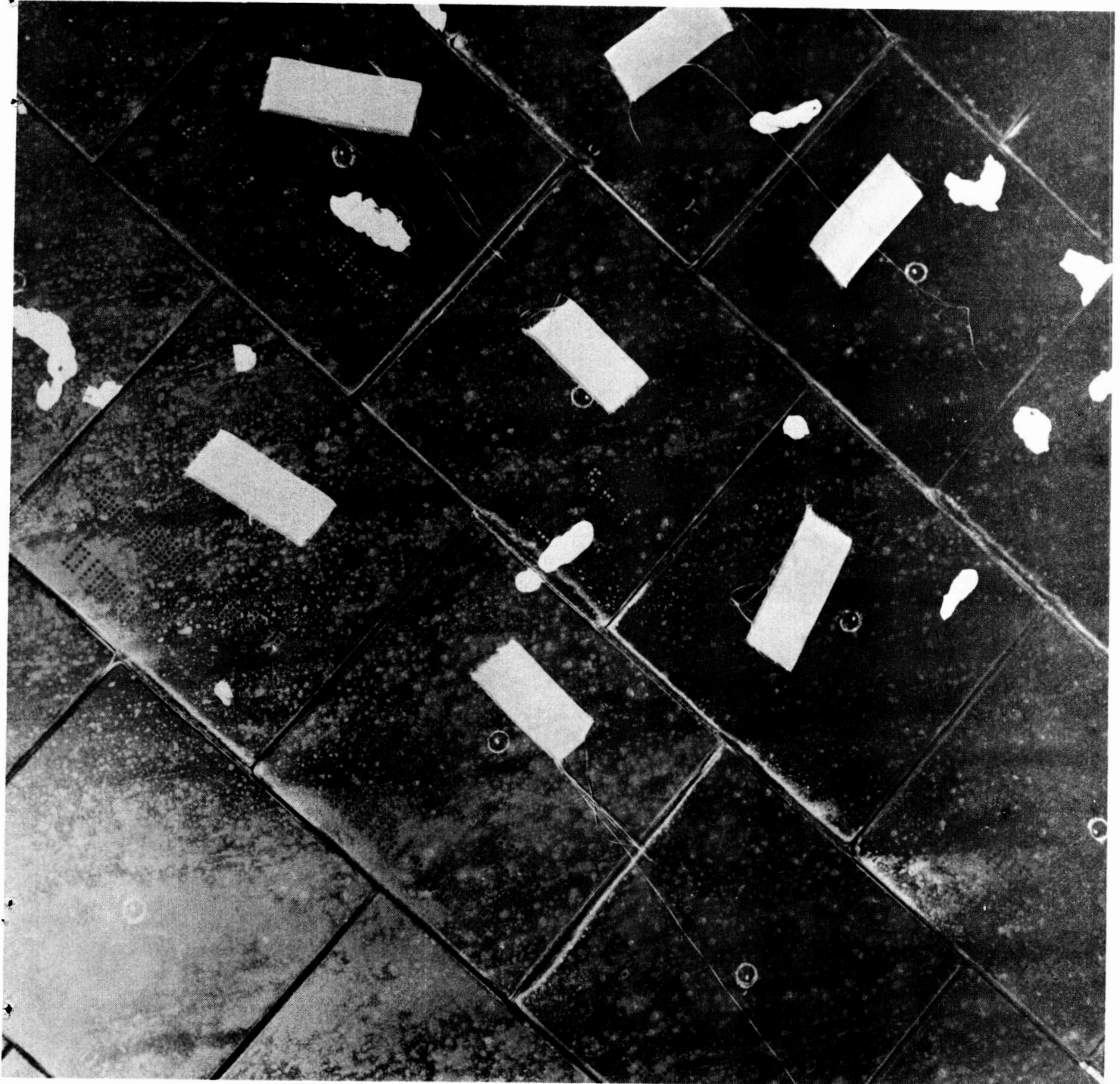
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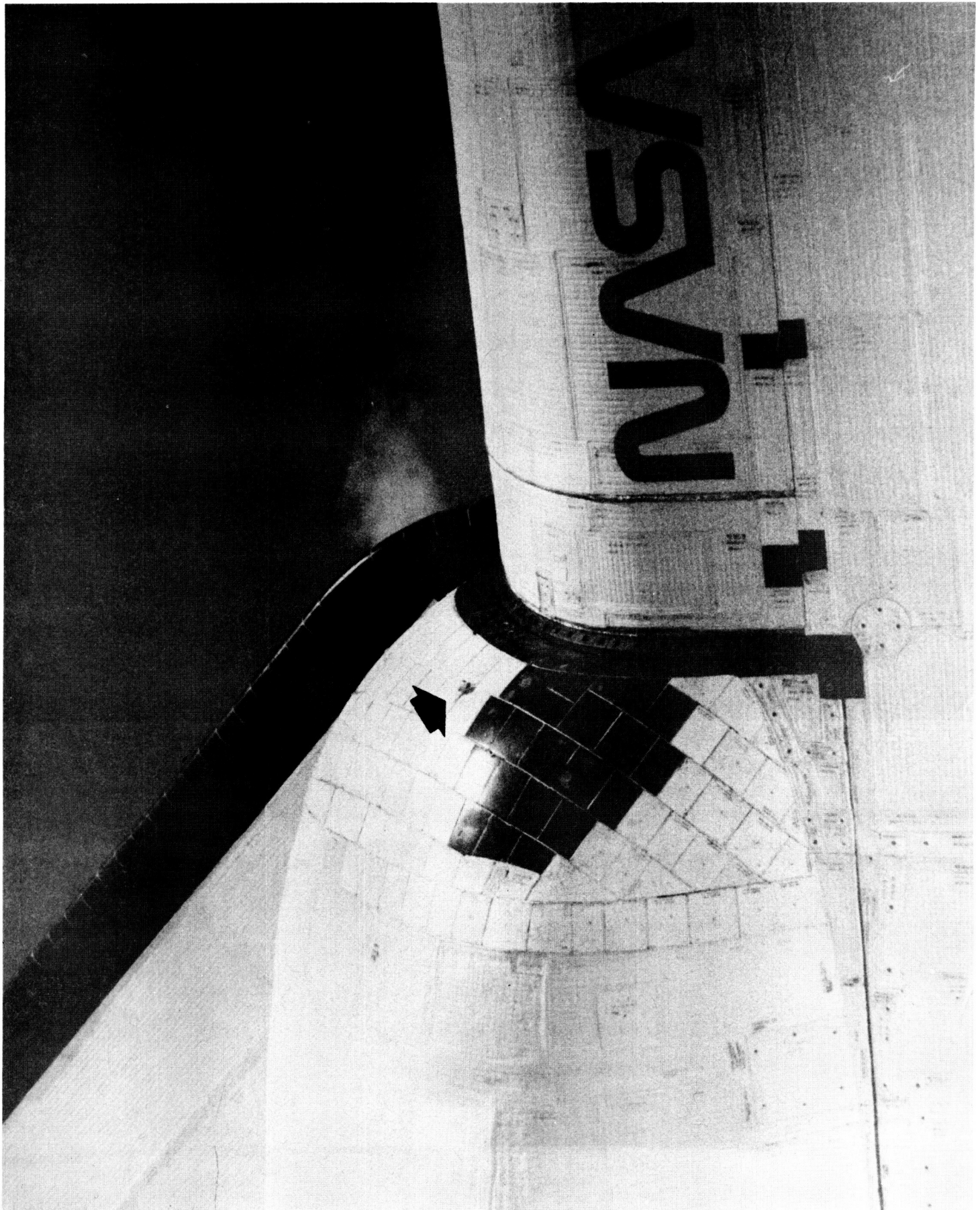


TILE DAMAGE ATTRIBUTED TO RUBBER
DEBRIS FROM TIRES DURING ROLLOUT

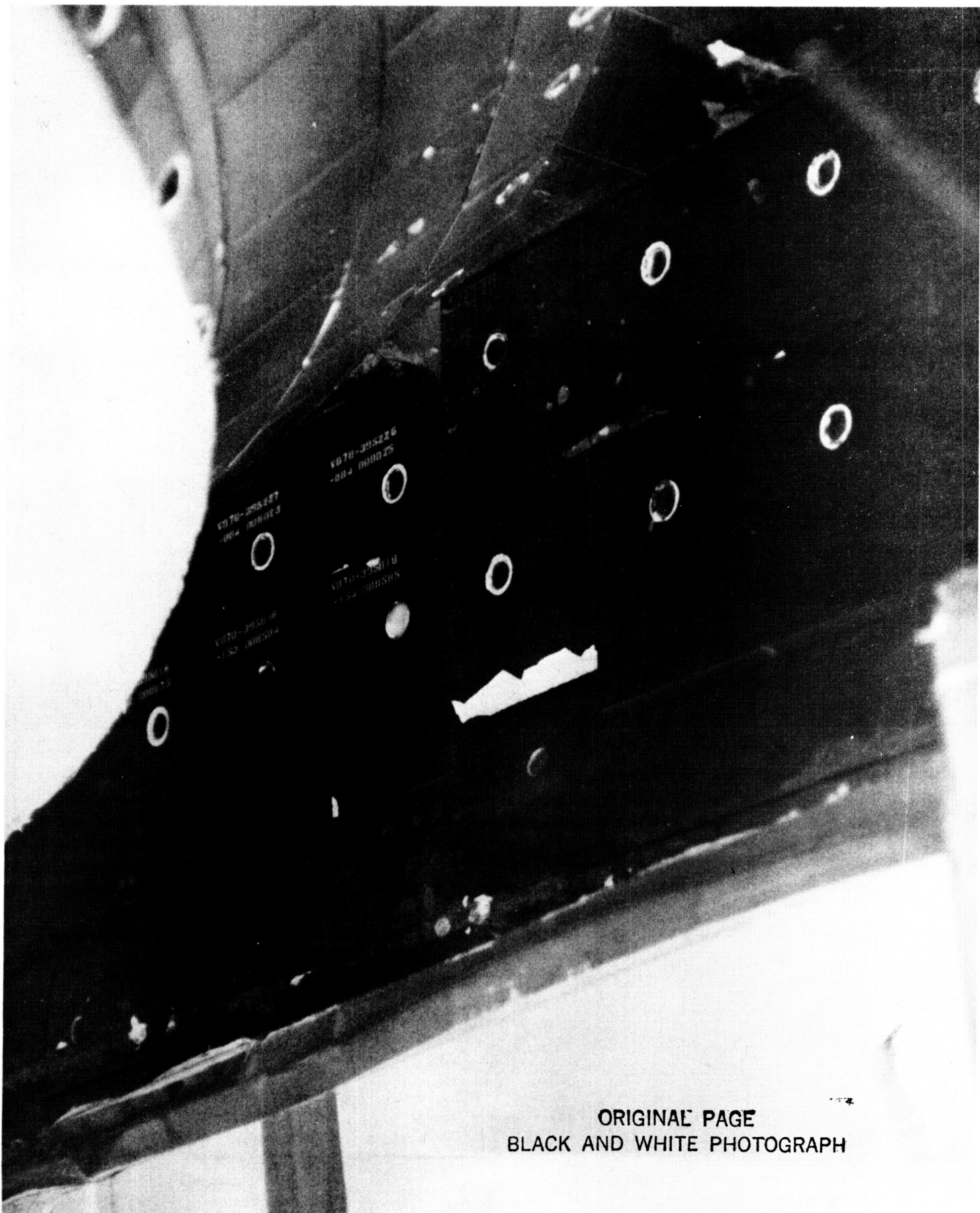
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BLACK AND WHITE PHOTOGRAPH



TILE DAMAGE DUE TO RUBBER DEBRIS FROM LH MLG TIRES



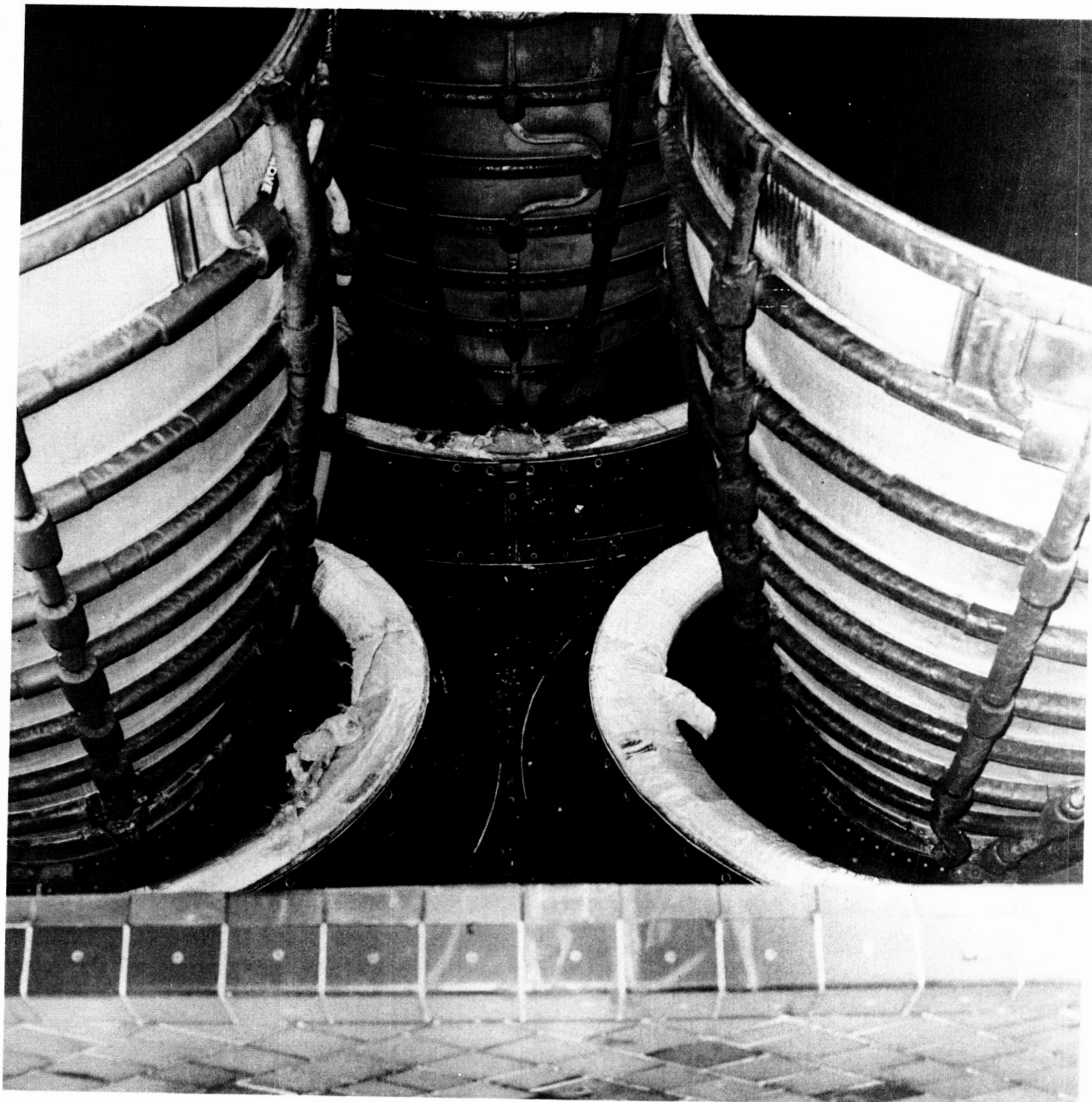
LOOSE SLEEVING MATERIAL ON THE FORWARD
AREA OF THE RH OMS POD DAMAGED ONE TILE



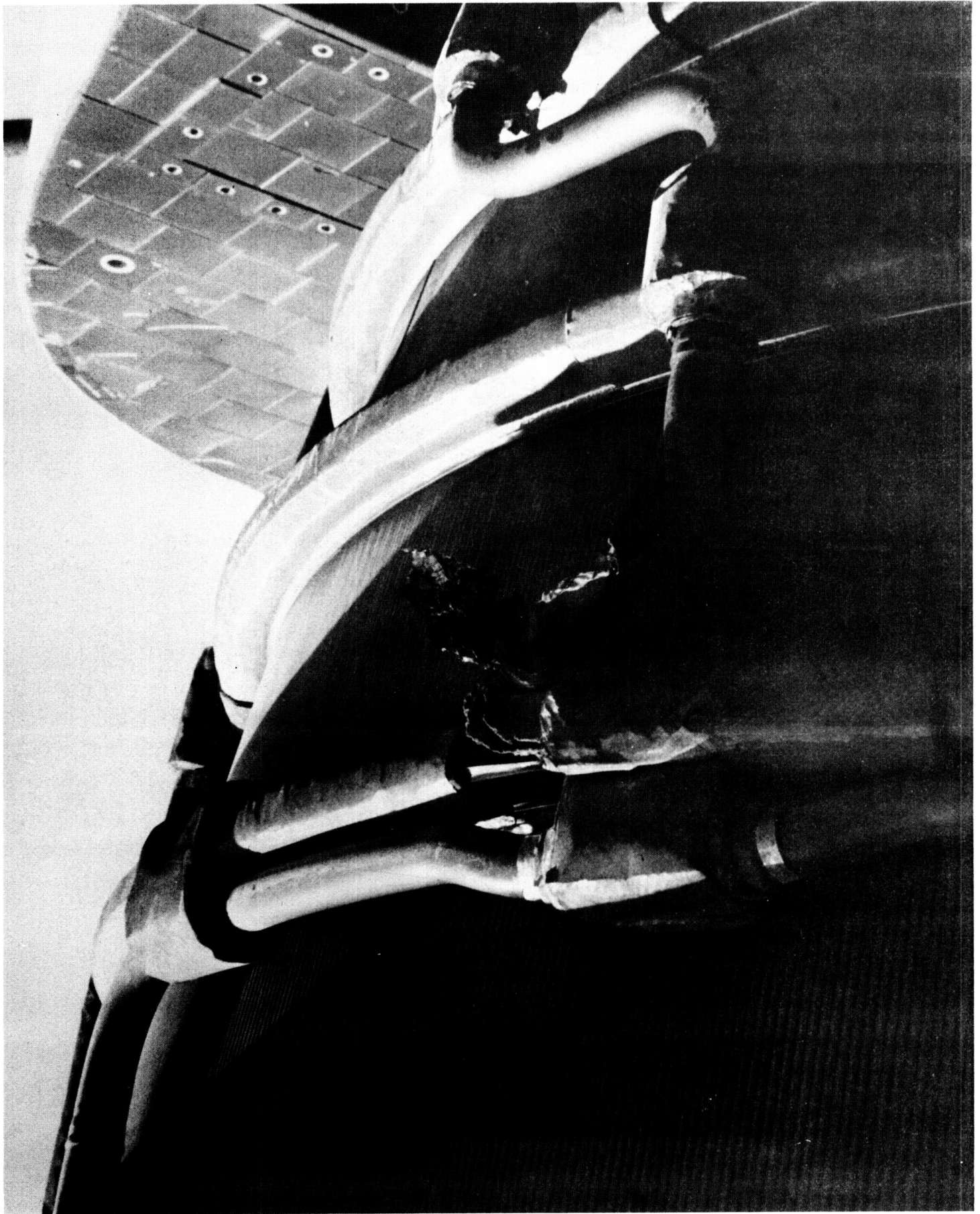
ORIGINAL PAGE
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MISSING TILE PIECE FROM THE UPPER SURFACE OF THE BODY
FLAP HINGE AREA THAT WAS OBSERVED IN LAUNCH FILMS

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BLACK AND WHITE PHOTOGRAPH



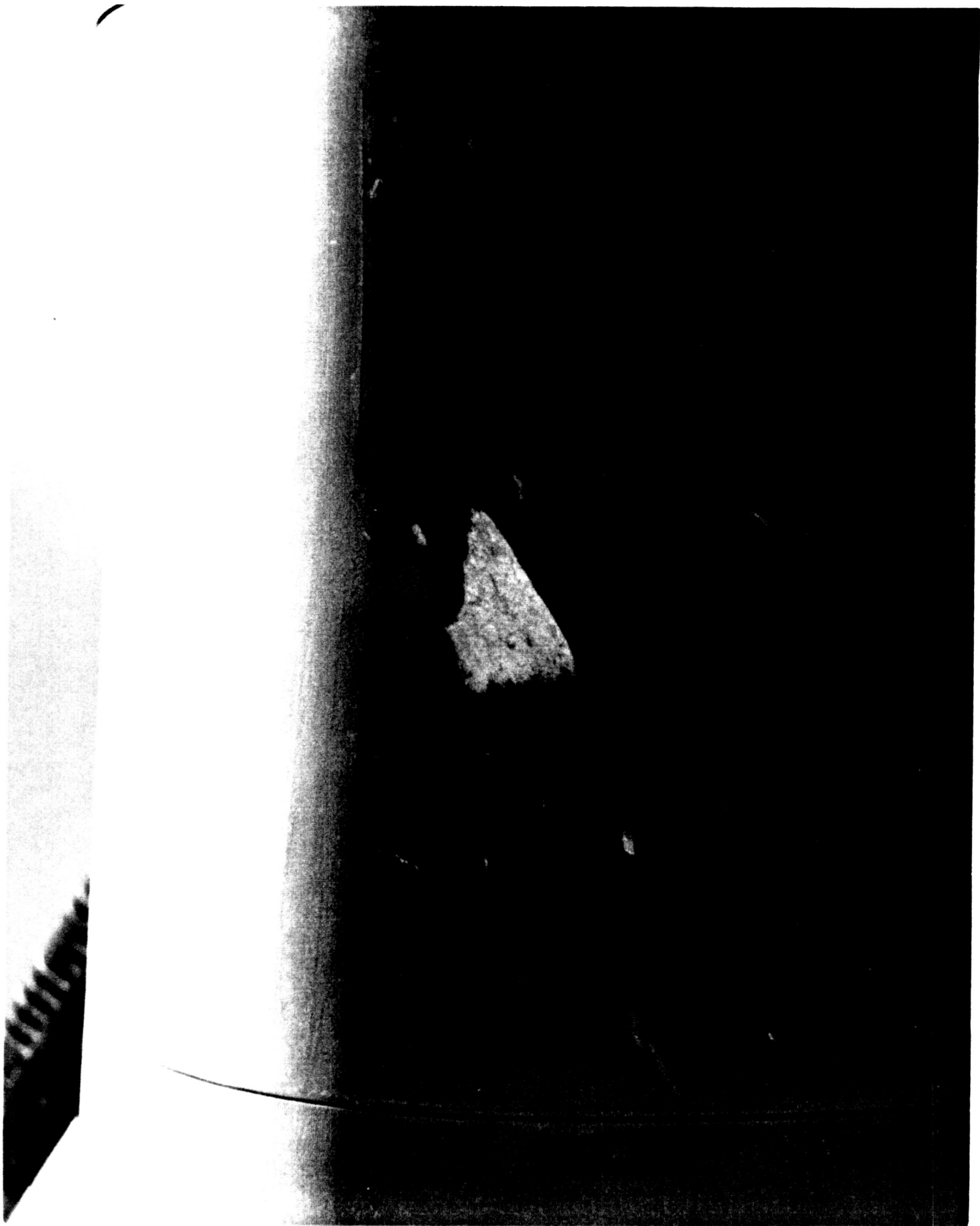
DAMAGE TO THE BASE HEAT SHIELD TILES WAS LESS THAN AVERAGE



DAMAGED AND LOOSE THERMAL BLANKET ON SSME #1 NOZZLE



WHITE STREAKS ON WING LEADING EDGE RCC

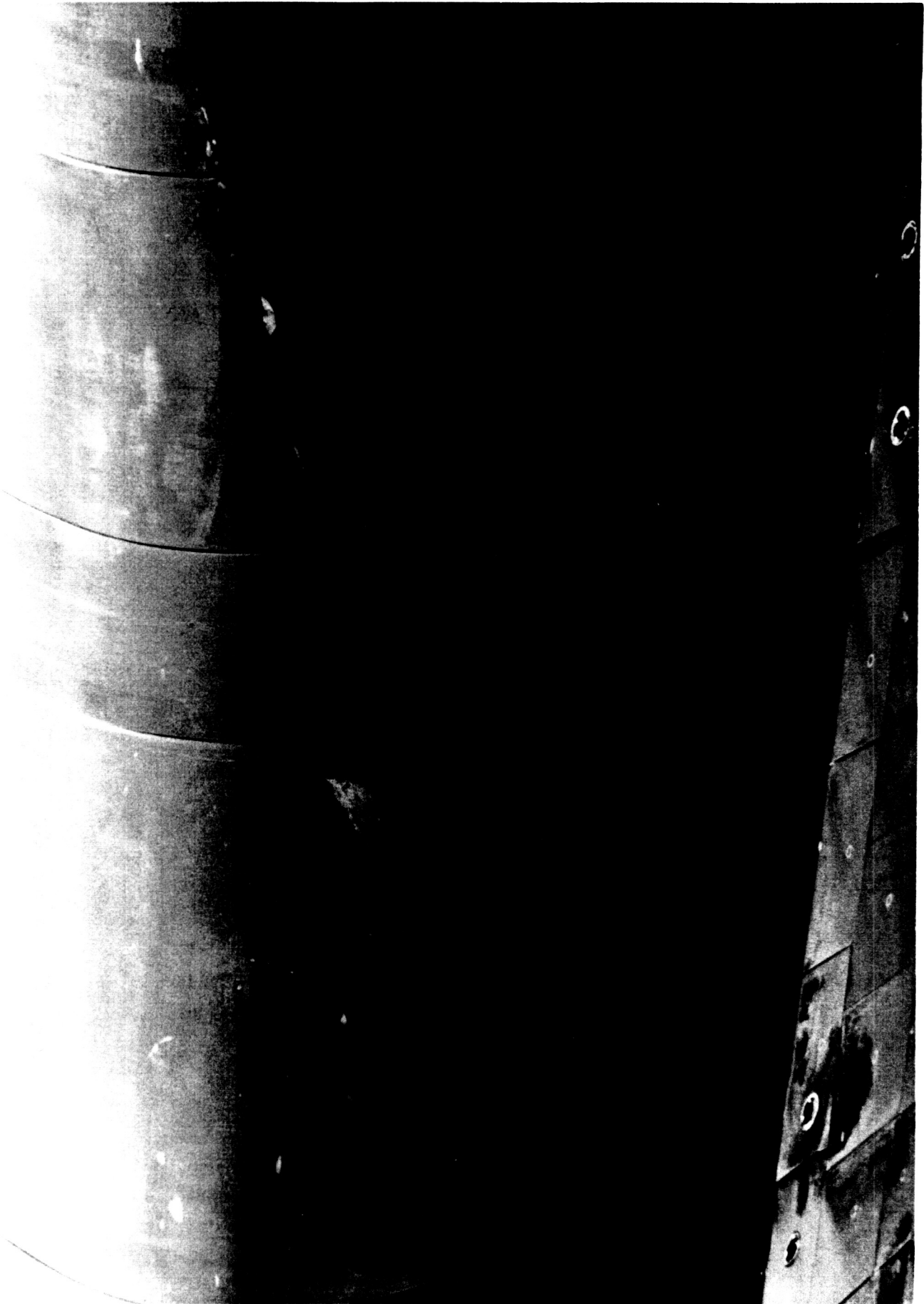


INSUFFICIENT QUANTITY OF STREAK MATERIAL
WAS AVAILABLE FOR ANALYSIS

ORIGINAL PAGE
COLOR PHOTOGRAPH

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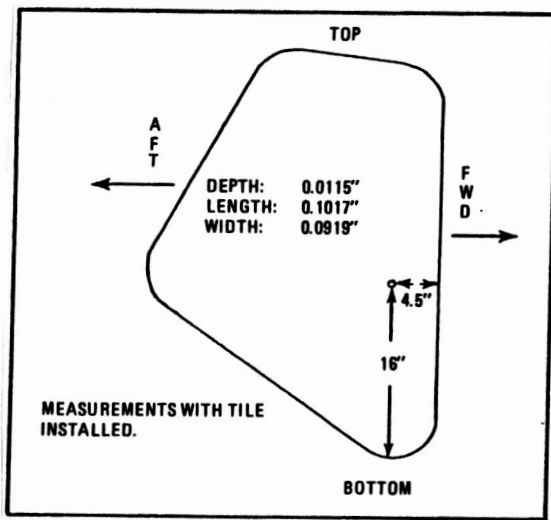
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ORIGIN OF MATERIAL THAT CAUSED STREAKS
ON WING LEADING EDGE RCC IS UNKNOWN

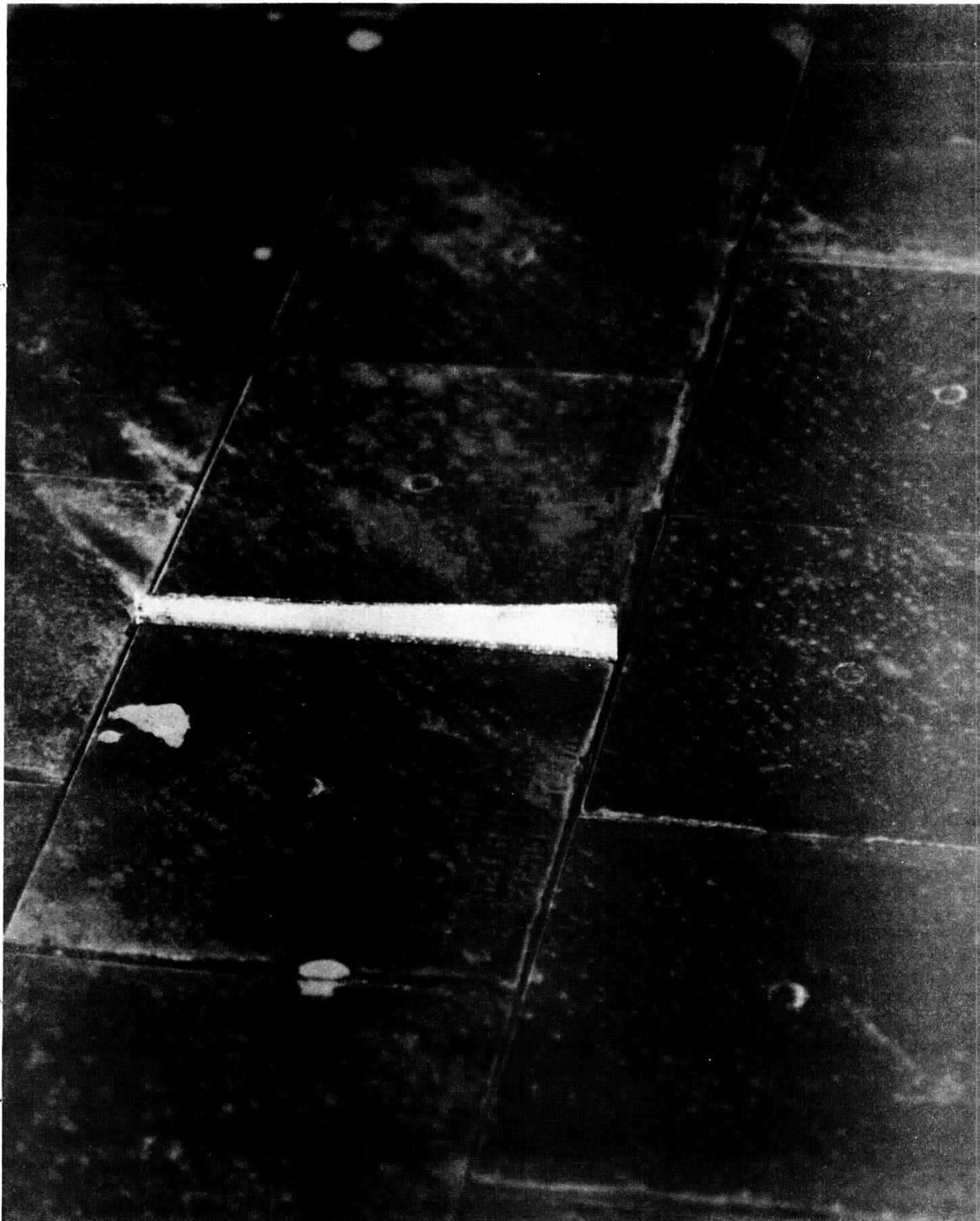
186

ORIGINAL PAGE
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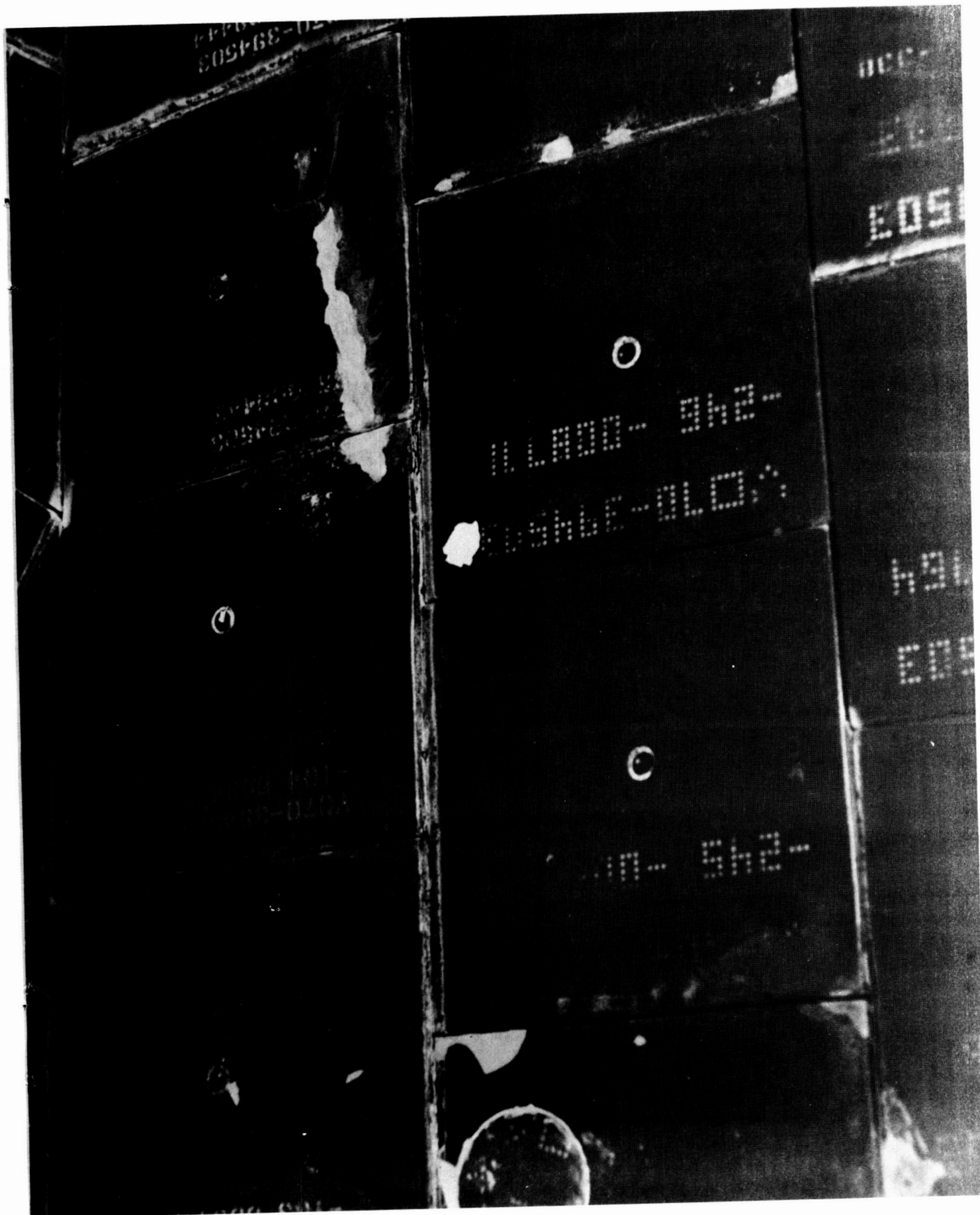
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DEBRIS IMPACT HIT TO WINDOW #6

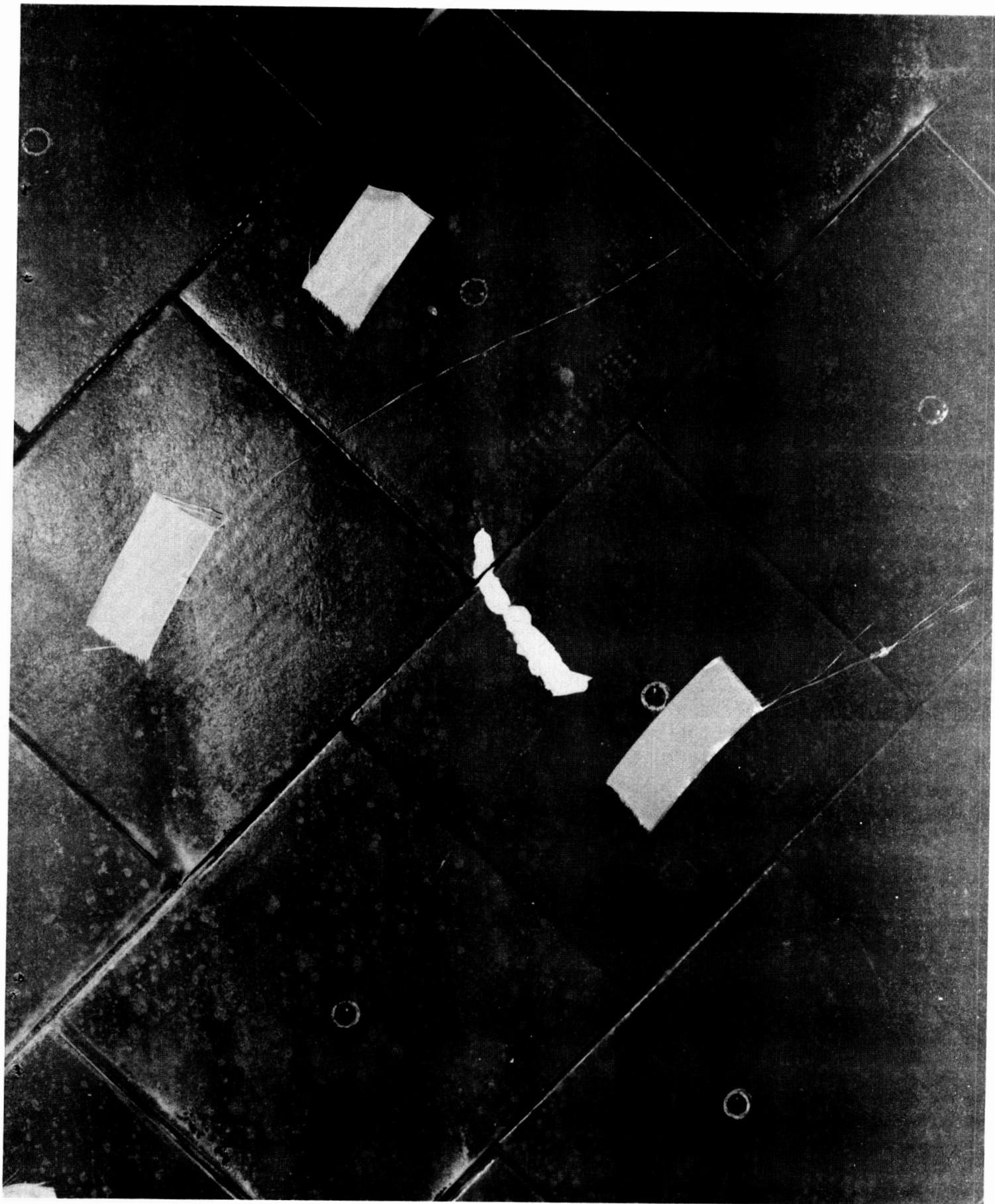


LOOSE AND PROTRUDING TILE GAP FILLER

C-3



FOREIGN SUBSTANCE ADHERING TO TILE



TYPICAL DEBRIS IMPACT DAMAGE



PURGE LINE TAPED CLOSED IN LO2 UMBILICAL ELECTRICAL CONNECTION

11.0 DEBRIS SAMPLE LAB REPORTS

A total of 19 samples were obtained from the STS-30R Orbiter vehicle during post-landing debris assessment operations at Ames-Dryden Flight Research Facility, California. The 19 submitted samples consisted of 8 Orbiter window wipes (W-1 through W-8), 6 tile samples (1 FWD RH sidewall, 2 FWD RH lower surface, 1 mid body RH lower surface, 2 AFT LH main landing gear door tire tread damage), and 5 wing RCC panel white streak samples (RH panels #7, 8, 9, 12 and LH panel #16). The samples were analyzed by the NASA-KSC Microchemical Analysis Branch (MAB) using optical microscopy (OM) and Electron Microprobe with Energy Dispersive Spectrometry (EDS). These analytical methods identified the samples in chemical element data form from which volume percentage estimates were made. The sample data were compared to known Shuttle element material data references. The specific elemental analysis is shown in Table 1 and 2 of Microchemical Analysis Branch Report MCB 417-89. These tables are for window wipes and tile debris. Insufficient quantity of wing RCC panel samples were available for analysis.

Results of the window samples analysis revealed the following materials deposited on Orbiter windows:

1. Small amounts of unidentified organics and organic fibers
2. Dust and salt materials composed of calcite, clay mineral, gypsum, alpha-quartz, silicate feldspar minerals, and pollen
3. BSM residue-type material and rust
4. Tile and gap filler fibers
5. Blue paint material
6. Red RTV rubber

Debris analysis would link organics/organic fibers to animal or insect remains and deposits. Dust, salt, and mineral deposits could be related to landing site products. BSM residue-type materials and rust are SRB separation products. The rust material could also be linked to the landing site. Tile, gap filler fibers, blue paint material, and red RTV rubber are most likely to be Shuttle element-type debris material.

Results of the tile debris analysis showed materials contained in tile samples were as follows:

1. White tile and dark dense tile
2. Black-reddish tile
3. Metallic materials - black, white sugary, gray woven, and red
4. Mineral materials - black shiny

Debris analysis of the tile debris samples shows some evidence of tile slumping. This finding indicates tile sample locations experienced re-entry heating effects. The inclusion of a mixture

of white and dense tile and gap filler materials shows orbiter debris within sample locations. Metallic materials are the most difficult to explain in terms of debris analysis. The corrosion products contained in two of the samples were of a 300-series stainless steel. The source of this debris material has not been identified. The mineral materials are typical of landing site debris items.

In addition to the window wipes, tile samples, and RCC streak samples, representative samples of the rubber material found on the runway during the post landing debris walkdown were submitted to the Microchemical Analysis Branch for comparison to orbiter tire material. Specimens of both the rubber runway debris and actual orbiter tire material were analyzed by infrared and thermal analytical techniques. The results of these tests are reported in Microchemical Analysis Branch Report MCB 423-89. These analyses indicated that all the specimens came from material of the same composition.

Several pieces of gray vinyl-like coating material were found on the MLP "0" level after the launch of STS-30R. A 5" X 5" piece was submitted to the KSC Microchemical Analysis Branch for chemical analysis testing. The analysis results show the material to be an epoxy resin-based coating with silica fillers and fibers. High-temperature decay tests revealed this material's ablative properties. Yellowish to black discoloration on one side of the sample indicated the coating came off of an iron alloy component. Although the precise source of this debris material is not presently known, analysis results indicate the source is an iron alloy that requires ablative protection.

MICROCHEMICAL ANALYSIS BRANCH
DM-MSL-1, ROOM 1274, O&C BUILDING
NASA/KSC
May 22, 1989

SUBJECT: Wipes and Scrapes from OV-104 Windows, Tile and
RCC Panels

LABORATORY REQUEST NO: MCB 417-89

RELATED DOCUMENTATION: Intercenter debris team requirements

1.0 FOREWORD:

1.1 REQUESTER: R.F. Speece/TV-MSD-22/7-0806

1.2 REQUESTER'S SAMPLE DESCRIPTION:

The samples were removed from OV-104 mission STS-30R landing, DFRF. The samples were identified as follows:

I. Window Wipes

1. OV-104, W-1, 5-8-89
2. OV-104, W-2, RH
3. OV-104, W-3, 5-8-89
4. OV-104, W-4, 5-8-89
5. OV-104, W-5, 5-8-89
6. OV-104, W-6, 5-8-89
7. OV-104, W-7, 5-8-89
8. OV-104, W-8, 5-8-89

II. Tile Debris

9. VO70-394022-119, RH MID body/WR surface
3/8" diam. impact.
10. VO70-191010-045, AFT LH MLGD Tire tread
damage
11. VO70-394048-252, FWD RH LWR Surface, black
residue
12. VO70-394048-242, FWD R/H Lower surface,
black residue
13. VO70-191010-049, AFT LH MLGD, Tire tread
damage
14. VO70-391011-286, FWD RH Sidewall, 3/8" diam
impact.

III. RCC Panel

15. RCC Panel #7, RH, White streaks
16. RCC Panel #8, RH White streaks
17. RCC Panel #9, RH White streaks

- 18. RCC Panel #12, RH, White streaks
- 19. RCC Panel #16, LH, White streaks

1.3 REQUESTED:

Determine composition and re-entry effects.

2.0 CHEMICAL ANALYSIS AND RESULTS:

2.1 Procedures:

The submitted samples were analyzed by means of optical microscopy (OM) and electron microprobe with energy dispersive spectrometry (EDS).

2.2 Results:

2.2.1 The particulates were classified into components on the basis of color and texture by OM.

2.2.2 Table 1 lists estimated amounts of each component by volume percent and elemental analysis by EDS from window wipes.

Table 1
Window Wipes

<u>Component ID</u>	<u>Elemental Analysis by EDS*</u>	
	<u>Major</u>	<u>Minor</u>
<u>#1 (W-1)</u>		
a. White mtl's (60)	Si, P, S, Ca, K	Cl, Fe, Al, Na
b. Orange flakes (32)	Fe, Si, Al, K, Ca	Mg, Ca, Ti, Mn
c. Black mtl's (1)	Fe, Si, Ca, S, K	Al, Zn, Cl
d. Blue mtl's (T)	Ti, Organics	Si
e. Glass fiber (2)	Si, Al	
f. Organics & fiber(S)	ND	
<u>#2 (W-2)</u>		
a. White mtl's (95)	Si, Al, K, Cl, S, Ca	Mg, Na, Ca, Fe
b. Orange flakes (T)	Si, Al, Fe, K	Ti, Mg
c. Black mtl's (1)	Si, Ca, Fe	Mg, Al, K, Ti, S, Zn
d. Glass fiber (T)	Si, Al	
e. Organics & fibers (4)	ND	
<u>#3 (W-3)</u>		
a. White mtl's (68)	Si, Al, Ca, K, Cl, S	Na, P, Fe
b. Orange flakes (30)	Fe, K, Al, Si	Ti, Mg
c. Black mtl's (2)	Si, Al, S, Ca	Cl, Fe, Mn, Ti, K
d. Glass & fiber (T)	Si, Al	
e. Organics & fiber (T)	ND	

#4 (W-4)

a. White mtls (85)	Si,Al,Ca,K,Cl,S	Na,Mg
b. Orange flakes (15)	Al,Si,K,Fe	Ca,Ti,Mg
c. Black mtls (T)	Fe,Si,Al,Ca	K,Mg,Zn
d. Glass fiber (T)	Si,Al	
e. Red mtls (T)	Si,Fe	
f. Organics & fiber (T)	ND	

#5 (W-5)

a. White mtls (95)	Si,Al,Ca,K	S,Cl,Na,Mg
b. Orange flake (5)	Al,Si,K,Fe	Ti,Mg,Zn
c. Black mtls (T)	Fe,Si,Al,Ca	K,Mg,Zn
d. Glass fibers (T)	Si,Al	
e. Organics & fibers (T)	ND	

#6 W-6)

a. White mtls (80)	Si,Al,Ca,K	S,Cl,Na
b. Orange flakes (20)	Al,Si,K,Fe	Mg,Ti,Ca
c. Black mtls (T)	Fe,Si,Al,Ca	K,Mg
d. Glass fibers (T)	Si,Al	
e. Organics & fiber (T)	ND	

#7 W-7

a. White mtls (5)	Si,Al,Cl,Ca,K	Na,S
b. Orange flakes (95)	Al,Si,K,Fe	Ca,Ti,Mg
c. Black mtls (T)	Al,Si,K,Fe	Mg,Ca,Ti,S
d. Glass fiber (T)	Si,Al	
e. Organics & fiber (T)	ND	

#8 W-8)

a. White mtls (3)	Si,Al,Cl,K	Na,Mg
b. Orange flakes (97)	Al,Si,K,Fe	Ti,Mg,Ca
c. Black mtls (T)	Si,Al,Fe,S	Zn,Ca
d. Glass fibers (T)	Si,Al	
e. Organics & fiber (T)	ND	

(3): Estimated volume percent

* : O,C,H and B are not detectable by using this technique

T : Trace

S : Small

2.2.3 Table 2 lists estimated amounts of each component by volume percent and elemental analysis by EDS from tile debris.

Table 2

Tile Debris

<u>Component ID</u>	<u>Elemental Analysis by EDS*</u>	
	<u>Major</u>	<u>Minor</u>
<u>#9</u>		
a. White tile (50)	Si	
b. Dark dense tile (30)	Si	
c. Black mtl's (20)	Fe,Cr,Al	Ni,S,Si

#10

a. White tile (68)	Si
b. Dark dense tile (30)	Si
c. Blk-reddish tile (2)	Si

#11

a. White sugary mtl's (2)	Ca,Si,Al	Ti
b. Black shiny mtl's (26)	Si	Ca
c. Gray woven mtl's (20)	Si,Ca,Al	Mg
d. Dark dense tile (2)	Si	
e. Red mtl's (T)	Si,Al,Fe,Ca	K,Ti

#12

a. White sugary mtl's (T)	Si,Ca,Al	Ti
b. Black shiny mtl's (100)	Si	Ca
c. White clear mtl's (T)	Si	

#13

a. White tile (50)	Si
b. Dark dense tile (50)	Si

#14

a. White tile (70)	Si	
b. Dark dense tile (28)	Si	
c. Black mtl's (2)	Fe,Cr,Al	Ni,S,Si

(50): Estimated volume percent

* : O,C,H, and B are not detectable by using this technique.

T : Trace

2.2.4 Figures 1 and 2 are scanning electron microscopy (SEM) photomicrographs of semi-spherical white

colored salt component and orange colored flakes, respectively, to show the morphological features.

2.2.5 Figure 3 is SEM photomicrograph of black shiny materials to show a combination of the mud-crack patterns and concoidal fracture surfaces.

2.2.6 The particles from sample numbers 15 through 19 (RCC panel) contained too small amounts to analyze by using instruments available in our laboratory.

3.0 CONCLUSIONS:

I Window Wipes

1. The particulates from all samples contained white materials, orange flakes, black materials, glass fibers and organics and organic fibers. The particles from sample #1 and sample #4 contained blue and red materials, respectively, in addition to above components.

2. The white materials appeared to be composed of a combination of dust and salt components. The OM data suggested that the dust materials could be composed of calcite (CaCO_3), clay mineral (Al-Si rich clay, possibly kaolinite, $\text{H}_4\text{Al}_2\text{Si}_2\text{O}_9$), alpha-quartz ($\alpha\text{-SiO}_2$), gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) feldspar minerals ($\text{NaAlSi}_3\text{O}_8$ - $\text{CaAl}_2\text{Si}_2\text{O}_8$), poorly crystallized materials, and pollen.

3. The orange colored flakes were composed of Fe, Si, K, Al contained materials.

4. The black materials were also composed of a combination of rust, dust and salt components with small amounts of organic components. The organics were not identified due to the small amounts of samples.

5. The glass fibers were composed of Si rich tile and Al-Si rich gap filler fibers.

6. The organics and organic fibers were not identified at this time.

7. The blue materials were identified to be paints and the red materials from sample #4 were identified to be room temperature vulcanizing (RTV) rubber.

II Tile Debris

8. The particulates from tile debris contained white tile, dark dense tile, black materials, white sugary materials, black shiny materials, white clear materials, grey woven materials, and red materials (Table 2).

9. Some particles of the dark dense tile surfaces contained white clear glassy materials. The OM data suggested that some of these particles were composed of poorly crystallized cryptocrystalline materials which might be caused by high temperature.

10. The black materials from sample #9 and #14 were composed of a combination of corrosion products of a 300 series stainless steel, aluminum rich materials (probably corundum, Al₂O₃) and Si-Al rich gap filler fibers.

11. The white sugary materials from sample #11 and #12 appeared to be composed of Ca-Si-Al rich materials.

1.2 The black shiny materials from sample #11 and 12 were composed mainly of Si rich materials with small amounts of Ca. The OM and SEM data indicated that the black shiny materials might be formed from the gap filler matrix phases at elevated temperatures. The morphological features suggested that these materials might be formed at high temperature.

13. Sample number 11 contained the broken and woven Al-Si rich gap filler fiber strands.

III RCC Panels

14. All samples did not contain enough particles for analysis. The samples were not analyzed.

15. The samples and tools are attached with this report.

CHEMIST: H. S. Kim
H. S. Kim

APPROVED: J. F. Jones
J. F. Jones



Figure 1
SEM Photomicrograph of Semi-spherical
Salt Component. #3. 240X



Figure 2
SEM Photomicrograph of Orange Colored
Flakes. #3. 220X



Figure 3
SEM Photomicrograph of Black Shiny
Materials. #11. 120X

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BLACK AND WHITE PHOTOGRAPH

MICROCHEMICAL ANALYSIS BRANCH
DM-MSL-1, ROOM 1274, O&C BUILDING
NASA/KSC
May 20, 1989

SUBJECT: Analysis of Runway Debris and Tire Specimen

LABORATORY REQUEST NO: MCB 423-89

1.0 FOREWORD:

1.1 REQUESTER: Scott Higginbotham/TV-MSD-22

1.2 REQUESTER'S SAMPLE DESCRIPTION:

1. Material taken from OV-104 Main Landing Gear Tire
2. Material found on EAFB Runway 22 shortly after OV-104 landing

1.3 REQUESTED: Comparative analysis of samples 1 and 2.

2.0 CHEMICAL ANALYSIS AND RESULTS:

2.1 The samples were examined and specimens from each analyzed by infrared and thermal analytical techniques.

2.2 Infrared spectroscopic techniques identified both the tire and the runway samples as polyisoprene rubber.

The acetone extracts of each sample and the chloroform extracts of each sample were comparable to each other thus indicating the same or very similar compounding of the rubber stocks.

2.3 Thermal analyses of the samples also indicated the same or very similar compounding formulations for the two samples.

	<u>Shuttle Tire Specimen</u>	<u>EAFB Runway Specimen</u>
Loss = % Polymer in N2 atmos. & additive	62.2%	64.3%
Loss in = % carbon O2 atmos. Black	30.5%	29.2%
Inorganics, and Residue	6.6%	6.6%
Onset of Polymer Loss	381.8 degrees C	383.7 degrees C
Onset of Carbon Black Loss	454.3 degrees C	457.7 degrees C

3.0 CONCLUSION:

The comparative analyses were certainly similar enough to indicate the rubber specimens came from material made to the same specifications.

More detailed analyses are certainly possible but do not seem necessary at this time.

CHEMIST: W. R. Carman
W. R. Carman

APPROVED: J. P. Jones
J. P. Jones

MICROCHEMICAL ANALYSIS BRANCH
DM-MSL-1, ROOM 1274, 0&C BUILDING
NASA/KSC
May 20, 1989

SUBJECT: Analysis of 5" X 5" Piece of Gray Vinyl-like Coating
Found on "O" Level of MLP-1 After STS 30 Launch

LABORATORY REQUEST NO: MCB 424-89

1.0 FOREWORD:

1.1 REQUESTER: Jim Draus/TE-FAC-2

1.2 REQUESTER'S SAMPLE DESCRIPTION

5" X 5" Piece of Gray "Vinyl-like" Coating

1.3 REQUESTED:

Determine composition

2.0 CHEMICAL ANALYSIS AND RESULTS:

2.1 The sample was examined and analyzed using infrared and other analytical techniques.

2.2 The material was identified as an epoxy resin based coating material. The material contains silica and siliceous fillers, including fibers, plus white specks of sodium pyrophosphate.

2.3 One side of the coating (the underside?) has a yellowish to black discoloration which is associated with a localized iron concentration and probably means the coating came off a ferrous alloy component.

2.4 Thermal analysis of the material showed a three step weight loss with a 49-50% residual after ignition to 900 degrees C.

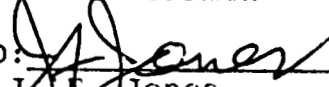
The first weight loss step occurred from ambient to 280 degrees - 550 degrees C was about 36.5 percent.

The final step to 900 degrees C yielded about 7% weight loss.

CHEMIST:


W. R. Carman

APPROVED:


J. F. Jones

12.0 POST LAUNCH ANOMALIES

Based on the debris inspections and film review, 20 Post Launch Anomalies were observed.

12.1 EXTERNAL TANK

Only one anomalies was observed for the External Tank (ET-29). It concerns the loss of foam particles the vehicle on ascent. These particles probably originated from the intertank area.

12.2 SOLID ROCKET BOOSTERS

Twelve anomalies were observed for the Solid Rocket Boosters (BIO-27) flown on STS-30R.

The first concerns the numerous MSA debonds found on the SRB frustums/forward skirts during the post flight inspection. Eighty-one debonds were detected on the RH SRB frustum, 1 on the RH SRB forward skirt, and 104 on the LH SRB frustum. These debonds represent potential debris sources.

Missing material/delaminations were detected on the SRB RSS antennae during the post flight inspection. These antennae are known debris generators, having lost material on both STS-29R and STS-30R.

Three factory joint EPDM weather seals were debonded on the LH aft segment. This failure allows sea water intrusion into the joint creating a corrosion problem.

A fifth SRB anomaly relates to the loss of cork and K5NA from the SRB aft BSM's. The loss of this material was noted during the post flight inspection. This anomaly has been noted on many previous missions.

The loss of instafoam from the SRB aft skirts was observed. Films from this and numerous prior STS missions have shown that a large quantity of instafoam is lost at liftoff and on ascent. Instafoam lost from the aft skirt on ascent could become damaging debris when transported by recirculating flow.

Six of the eight aft skirt holddown post debris containers did not function properly. Many pieces of booster cartridges, detonators, and frangible nut were lost from the containers as a result of the debris plungers not seating properly. These failures are a debris concern.

The eighth SRB anomaly concerns the blistering and loss of both white and black Hypalon paint from the SRB frustums and forward skirts. The blisters range in size from 1/8 to 5 inches and many have MSA-2 ablator attached to the paint. This phenomenon has been noted on many previous missions and is a debris concern.

The LH SRB main parachute #2 failed to inflate upon deployment. This caused the booster to impact the ocean at a higher than nominal velocity. Examination of the recovered hardware and the onboard camera deployment film has failed to determine the reason for the failure.

- Epon holddown post shim material was lost from the SRB aft skirts in 3 areas.

- Upon recovery of the LH SRB it was discovered that 20 to 25 gallons of sea water had entered the LH forward skirt. The intrusion of sea water into the forward skirt has been noted on several prior flights and represents an unsolved design problem. This anomaly presents a corrosion problem to the electronic assemblies in the forward skirt.

The twelfth SRB anomaly concerns the loss of GEI MSID labels from both SRBs. Post flight inspection revealed that 42 of these labels were completely missing and 22 were partially missing from the boosters. These labels are 1-1/4" X 6" in size and are covered with a 1/8" thick layer of epoxy, making them a debris concern.

Three bolts were sheared on the LH SRB ET ring cover. This failure was observed during the post launch SRB inspection.

12.3 ORBITER

Seven STS-30R Orbiter anomalies were observed for OV-104 (Atlantis).

A 6"X3"X1" piece of black tile was broken from the body flap hinge area at SSME ignition. This tile anomaly was first noted during the review of several launch films and was confirmed during the post landing Orbiter inspection.

The second Orbiter anomaly observed was loose thermal insulation on SSME #1 hat band #7. This insulation came loose during SSME ignition and was detected during launch film review.

The Post landing Orbiter inspection revealed that window #6 suffered impact damage while in flight. The damaged area measures 0.102"X 0.092"X 0.0115" and is severe enough to require window replacement.

Shortly after Orbiter landing, a pyrotechnic retainer yoke fell from the ET/ORB LO2 umbilical to the runway surface. This anomaly was also observed on STS-26R.

The fifth Orbiter anomaly concerns numerous missing/loose gap fillers detected during the post landing Orbiter inspection. Gap fillers lost in flight represent a debris damage source.

During the post landing Orbiter inspection it was noted that a purge line was taped closed in the LO2 umbilical electrical connection.

The Orbiter LH main landing gear tires shed rubber material upon landing. This tread material was thrown upward into the lower surface of the vehicle causing considerable tile damage. In the area immediately aft of the LH MLG there were 70 tile damage sites, 45 of which had a major dimension greater than one inch.

12.4 FACILITY

No anomalies were attributed to the facility for this mission.

Report Documentation Page

1. Report No. Tm 102147		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle KSC Ice/Frost/Debris Assessment for Space Shuttle Mission STS-30R				5. Report Date May 1989	
				6. Performing Organization Code TV	
7. Author(s) Charles G. Stevenson Gregory N. Katnik Scott A. Higginbotham				8. Performing Organization Report No.	
				10. Work Unit No.	
9. Performing Organization Name and Address NASA External Tank Mechanical Systems Section Mail Code: TV-MSD-22 Kennedy Space Center, Florida 32899				11. Contract or Grant No.	
				13. Type of Report and Period Covered	
12. Sponsoring Agency Name and Address				14. Sponsoring Agency Code	
15. Supplementary Notes					
16. Abstract An Ice/Frost/Debris assessment was conducted for Space Shuttle Mission STS-30R. Debris inspections of the flight elements and launch pad are performed before and after launch. Ice/Frost conditions on the External Tank are assessed by the use of computer programs, nomographs, and infrared scanner data during cryogenic loading of the vehicle followed by an on-pad visual inspection. High speed photography is analyzed after launch to identify ice/debris sources and evaluate potential vehicle damage. This report documents the Ice/Frost/Debris conditions of Mission STS-30R and their overall effect on the Space Shuttle Program.					
17. Key Words (Suggested by Author(s)) STS-30R Ice Frost Debris Thermal Protection System				18. Distribution Statement Publicly available Unclassified - Unlimited	
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of pages	
				22. Price	